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PROPERTIES AND UTILIZATION OF PETROLEUM WAXES.

By C. G. Gray.

The waxy materials derived from petroleum are classified * into three main groups: (1) the paraffin-wax group; (2) the petrolatum group; and (3) the petroleum ceresin group. This classification is based mainly upon crystal size, consistency, and method of manufacture. Although both natural and artificial mixtures of the three classes are encountered, so that borderline cases exist, nevertheless the three classes possess distinctive properties, so that in general each class is particularly suited to certain specialized types of application. It will therefore be convenient to consider the properties and applications of each class separately.

1. The Paraffin-Wax Group.

General Properties.

The waxes in this group are solids with a relatively pronounced crystalline structure. They consist mainly of mixtures of normal paraffin hydrocarbons in the range C_{18} to C_{35} approximately. Their setting points range up to about 160° F., and their mean molecular weights are normally in the range 225–450. In practice they are almost invariably derived from distillates.

Although no strict line of demarcation is laid down, a distinction is drawn between *refined paraffin wax* and *paraffin scale wax.* Refined paraffin wax is a paraffin wax of very low oil content, and is a colourless, translucent wax which is not more than slightly greasy to the touch. It is practically odourless and tasteless. Refined paraffin waxes may have setting points ranging from about 90° to 160° F. Scale wax, on the other hand, may contain a considerable proportion of oil, and its solid components normally cover a wider melting range than those of refined grades, which, in fact, are usually manufactured from scales by sweating, or fractional melting, to remove practically all the oil and to separate the solid components into cuts of narrower melting range. The setting point of scale wax may range from about 90° to 140° F. Scale waxes may be oily to the touch, and are frequently crumbly or flaky in texture.

Physical Properties.

Paraffin waxes melt to clear colourless liquids of low viscosity.

The density of the solid varies between the approximate limits of 0·90 and 0·94 at 20° C. On melting, there is considerable expansion, the density of molten paraffin waxes being about 0·77 just above the melting point.

The principal thermal properties are as follows: Specific heat of solid, about 0·5, but higher values may be shown at temperatures near the melt-

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* Report of Nomenclature Panel of I.P. Committee No. 8 (Petroleum Wax), *J. Inst. Petrol.*, December 1943, 29, (240), 361.

ing point, owing to the absorption of heat energy by crystalline changes. The specific heat of the liquid is given by the approximate expression $C = 0{\cdot}492 + 0{\cdot}0009t^\circ$ C. at temperatures between the melting point and 300° C. The latent heat of fusion is about 40 cals./gm. The heat conductivity of the solid increases very rapidly with temperature, being about 0·00023 at 0° C. and 0·0006 at 25° C., in units of cals./sec./cm. cube/°C.

The electrical resistance of paraffin wax is very high—of the order 10^{17} ohms/cm. cube at room temperature. It shows a general rapid decrease as the temperature rises to the melting point, but once again crystalline transitions give rise to irregular variation as the melting point is approached. The dielectric constant is about 2·0.

Paraffin wax is completely insoluble in water, and is not readily wetted. It is to some extent soluble in petroleum fractions, turpentine, chlorinated solvents and, generally, in non-polar organic solvents. The solubility in, *e.g.*, white spirit increases rapidly with temperature. The wide variations possible in grades of wax and in composition of solvents makes it impossible to lay down definite limits, but a typical case is that of a 135–140° F. setting-point wax, which dissolves to the extent of 2 per cent. in an aromatic white spirit at 15° C., and to the extent of 46 per cent. weight at 40° C. D. S. Davis (*Industr. Engng. Chem., Ind. Ed.*, 1940, 32, 1293) gives a nomograph relating the solubility of paraffin wax in petroleum fractions to the properties of the wax and of the solvent.

Chemical Properties.

Paraffin waxes are very stable chemically, a fact to which the name "paraffin" is due. They resist the action of concentrated acids and alkalis. At elevated temperatures they react with oxidizing or halogenating agents. The oxidation products are mainly fatty acids and hydroxy acids. Halogenation gives rise to substitution derivatives, those of higher halogen content being viscous liquids.

When burned under suitable conditions, paraffin wax gives rise to a clear flame, which is nearly white, smokeless, and odourless.

Applications of Paraffin Waxes and Scales.

In the years immediately prior to 1939, the world consumption of paraffin wax had reached the total of 500,000 tons per annum. Practically the whole of this quantity was absorbed in the manufacture of candles, waxed paper and cartons, polishes, matches, and electrical insulation materials, the distribution of the demand among these applications being approximately as follows :—

	Per cent.
Candles, nightlights and tapers	64
Waxed paper and cartons	15
Polish materials	10
Matches	5
Electrical insulation	3
Various other applications	3
	100

The demand for white scale wax is small in comparison with that for refined grades, most of the scale wax disposed of being used for the manufacture of nightlights and candles, and in minor applications such as barrel waxing.

(1) *Candles, Nightlights, and Tapers.*

Modern wax candles are manufactured by allowing the molten wax mixture to solidify in tubular tin moulds, the wicks being held centrally in the moulds while the wax is solidifying.

Since temperature control is of considerable importance during moulding, the moulds are surrounded by a water-bath, whose temperature may be adjusted by the introduction of cold water or of water which has previously been heated by injecting steam into the feed-line. The moulds are mounted vertically between metal end-plates which form the top and bottom of the water-bath. The bottom of each mould consists of a close-fitting piston, which is drilled centrally to allow the wick to be passed through it and upwards along the axis of the cylindrical mould. The upper surface of this piston is concave, and forms the tip of the candle, which is moulded in the inverted position. After solidification and cooling, the candles are ejected upwards from the moulds by raising the pistons. The candles are then gripped in a special type of clamp, and on lowering the pistons to the bottom of the now empty moulds, the machine is ready for moulding a new batch of candles. Fresh wick has been drawn from spools below the moulds, and is now supported centrally by the pistons at the lower end and by the finished candles at the upper end. The moulds are now refilled by the operator, the wax being allowed to flow from a pail over the top plate of the machine until all the moulds are filled, and a layer of wax about half an inch deep covers the plate, to allow for shrinkage into the moulds during solidification and cooling. The cooling water is usually maintained at 50–70° F., according to the wax being used. The wicks joining successive batches of candles are severed by a special knife when the new batch has solidified to an extent which makes support of the wicks from outside unnecessary.

The rack containing the finished candles is then removed and emptied. Before ejecting the next batch from the moulds, it is necessary to trim off the excess wax which covers the top plate of the machine and which still joins the bases of the candles. This operation is carried out by means of a broad spudding chisel when the wax is still plastic enough for easy handling, but cool enough to ensure that further shrinkage into the bases of the candles will be negligible. The excess portions of wick are removed with the wax fillet, which goes back for reboiling.

Fig. 1 shows in diagrammatic form the construction and operation of a single unit of the moulding machine. The modern machine contains up to 518 such moulds, together with water-bath, wick-bobbin compartment, hand-operated ram for raising the pistons, removable rack for holding the finished candles on ejection, and water and steam lines for temperature adjustment. Special types of moulds may be used to produce candles with fancy shapes, or with shaped butts.

Refined grades of paraffin wax with setting points of 120–145° F. are most commonly employed for candle manufacture. The setting point of the wax to be used must be chosen with due regard to the temperature conditions which are likely to apply where the candle is to be stored and used, these conditions in turn depending on the geographical location of the market. Too low a setting point gives a candle which softens and may bend during storage or use; too high a setting point, on the other hand, gives a candle which is difficult to light and which burns with a very short wick and a small flame.

There is now a considerable amount of evidence showing that the composition of the wax also plays an important part in determining its suitability for candle manufacture. For example, the moulding characteristics, tendency towards cracking and mottling, and tendency to give plastic flow at room temperatures, all of which are properties which must be taken into account by the candle manufacturer, are bound up with the degree of fractionation of the wax, and not merely with its setting point.

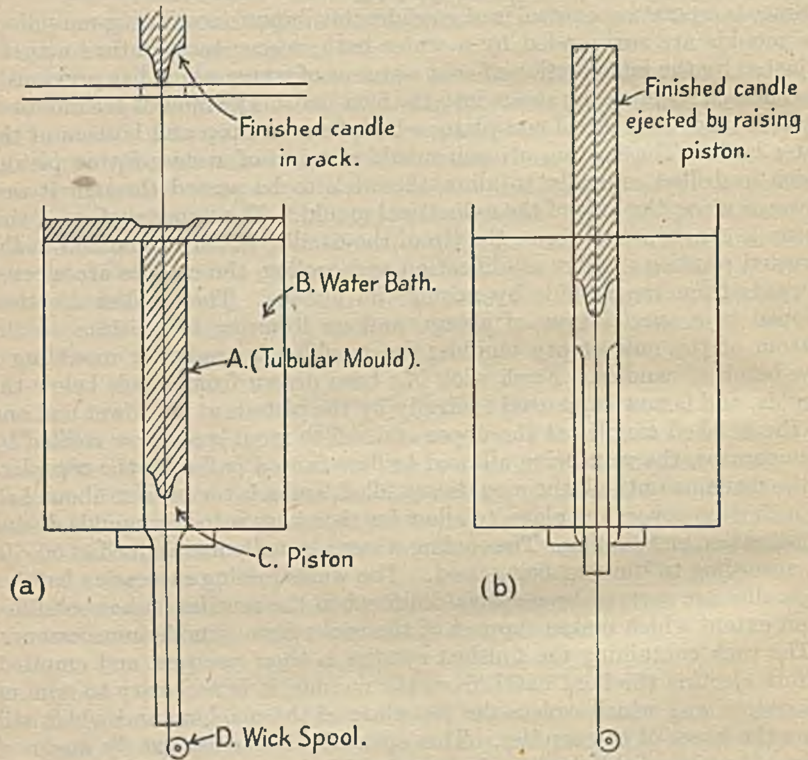

FIG. 1.

DIAGRAM OF SINGLE UNIT OF CANDLE-MOULDING MACHINE.

It is now normal practice to add a proportion of stearic acid to the paraffin used for candle-making. The proportion of stearic acid may vary according to special requirements, but is usually of the order of 5 per cent. in the case of paraffin wax of low setting point (120° F.). The proportion may be reduced in the case of higher-setting wax. The stearic acid improves the appearance of the candle, giving the wax a smooth, marble-like appearance. Moreover, it improves the strength of the wax, giving better "snap" at low temperatures and increased resistance to bending (plastic flow) at high room-temperatures. Contrary to the opinion which is sometimes expressed, the addition of stearic acid to paraffin wax in the proportions indicated usually produces a mixture whose melting point is lower than that of the original paraffin wax, so that the beneficial effects of the stearic acid on the mechanical properties of paraffin wax should not be confused with increase of melting point.

The wax and stearic acid are melted together by means of open steam, and since it is necessary to ensure that the moulding material is quite free from infusible solid particles of any kind, the melting and boiling are carried out over weak sulphuric acid, which destroys traces of metallic stearates and absorbs any fibrous particles which may have found their way into the wax or stearic acid from bags or packing materials. At this stage, too, the "reboilings" are added, containing portions of wick material, which are removed in the process of reboiling and settling. After melting and boiling, the mixture is allowed to settle, and when it has cleared it is run off into the steam-jacketed pans, from which the moulding-machine operator fills his pail.

The wicks are of cotton, and are plaited from three strands. The number of threads in each strand is varied in accordance with the size and type of candle being made. The nature of the wick influences the rate of consumption of wax, which in turn must be correlated with the diameter of the candle. Before use, the wicks are bleached and washed, and are then "pickled" in a solution of inorganic or organic salts, centrifuged and dried. The pickling salts commonly used include borax, ammonium phosphate, potassium nitrate, etc. Their purpose is to reduce char formation on the wick during burning and to eliminate smouldering of the wick on extinction of the candle. The pickling process may also be adjusted to influence the degree of curvature taken up by the wick while the candle is burning, this being of great importance in obtaining a candle which burns clearly and steadily with a good flame. The wick curvature is also affected by the weave of the wick and by the setting point of the wax employed.

Candles made by standard methods may vary in size from the tiny decorative "birthday cake" lights on the one hand, to church candles 60 inches high and 2½ inches in diameter on the other. References to larger ceremonial candles are encountered (for example, a candle 18 feet high and 7 feet in circumference is burnt in Naples for one day each year in memory of Caruso). Such candles, however, are presumably constructed by special methods, and it is doubtful whether paraffin wax enters into their composition to any great extent.

Nightlights are designed to burn more slowly than candles, giving a feebler illumination over an extended period. They may be moulded in a machine generally similar to the candle-moulding machine, except that the wick is not in place during moulding. Instead, a wire extends upwards through the mould, leaving a central hole in the nightlight, into which the wick is inserted by hand. The fine cotton wick is coated with a high-melting wax which stiffens it so that it can be inserted readily. This coating also supports a portion of the wick during burning and prevents its collapse into the cup of molten wax.

Two main varieties of nightlights are made, respectively with and without paper cases. In each type the wick is fastened to a small sheet-metal sustainer. In the manufacture of paper-cased lights, the wick and its sustainer are fastened to the prepared case by means of a hard wax of the sealing-wax type, the wax blank then being slipped into the case with the wick threaded through it. Uncased lights, which are designed to be burnt in glasses or in various appliances such as continental teapot warmers, are prepared simply by inserting the wick and its sustainer directly into the wax blank.

An alternative method for the manufacture of nightlights consists in warming the wax until it is plastic, and rolling or extruding the plastic mass into rods of approximately the required diameter, which are then cut into portions, each of which contains sufficient wax for one nightlight. These portions are then pressed to shape in steel moulds, under hydraulic pressure, giving blanks, which are finished off by inserting the wicks and fitting the nightlights into paper cartons.

Nightlights are made from paraffin wax alone, without the addition of stearic acid. A low-melting grade of wax (about 120° F.) is normally used, and white scale wax may be incorporated.

Wax tapers are made by passing the wick material through successive baths of molten wax, the wax coating being built up in stages and controlled by passage through a die of the appropriate size, after each dipping. The conditions are adjusted to ensure that the wax is in the plastic condition when it passes through the dies.

(2) *Waxed Paper and Cartons.*

Modern methods of production and marketing, whereby perishable goods manufactured in one hemisphere may be destined for consumption in the other, have brought with them the need for new and greatly improved wrapping materials, impervious to air, water, and water vapour, odourless, tasteless, physiologically inactive, robust enough and cheap enough to be commercially practicable. Waxed paper and cartons have obvious limitations as regards robustness, but fulfil all the other requirements. For certain applications in which great strength and rigidity are not essential, therefore, their use is extending very rapidly.

Waxed paper alone may be used as a wrapping material for a great variety of products such as bread, confectionery, beef-extract cubes, soap tablets, and safety-razor blades. Again, many proprietary materials are packed in unwaxed or lightly waxed cartons or boxes, which are then wrapped and sealed in waxed paper. This method is customary in the case of dry, granular products such as breakfast cereals, macaroni, salt, etc. It is also commonly used for biscuits. Lastly, liquid or semi-liquid products are conveniently handled in heavily waxed sealed cartons without any additional wrapping. The last method is familiar in the case of milk, honey, syrup, sandwich pastes, and so on.

Three main types of waxed paper may be distinguished: (1) impregnated or "dry waxed" paper in which the wax is completely absorbed into the paper web; (2) surface waxed on one side only; (3) surface waxed on both sides ("self-sealing paper"). The first type is used almost exclusively for retail wrapping of moist or greasy foodstuffs, and is therefore widely known as Delicatessen Paper. Paper waxed on one side is occasionally used for wholesale packaging; in general, however, double-waxed self-sealing paper finds the widest application. Possibly the largest single application of this type of paper is for wrapping of bread. In certain countries, notably the United States of America, wrapped bread is the rule rather than the exception. When using this type of paper, the package is hermetically sealed by folding the wrapper so that the edges overlap, then hot-pressing the overlap so that the wax melts momentarily and seals the flap on resolidification. The operation is carried out on specially designed machines with continuous conveyor feeds.

Paper-waxing machinery varies greatly in design and method of operation, but two basic types may be distinguished, according to whether the wax is applied to the paper by waxed rollers or by total immersion of the paper in molten wax.

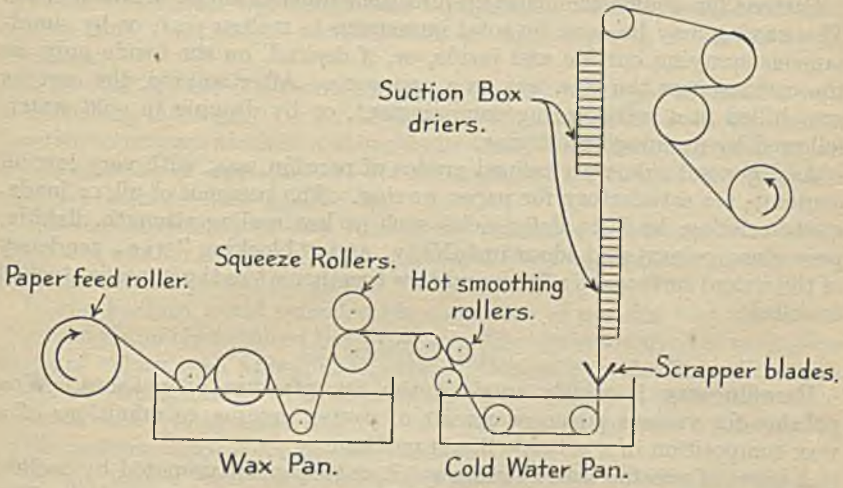

FIG. 2.

DIAGRAM OF PAPER-WAXING MACHINE.

Needless to say, single-waxed paper is produced by roller waxing. By suitable arrangements for turning the paper strip as it is fed through the machine, double waxing may be carried out in two stages on this type of machine. There are also machines in operation in which the paper is waxed on both sides simultaneously by passage between rollers, the lower roller rotating half-immersed in the wax-bath, and the upper one being fed with molten wax by means of a pump.

In the immersion type of waxing machine (see Fig. 2) the paper strip is fed from the roll over heated rollers and then through the wax-bath. On leaving the wax-bath, the paper passes through adjustable "squeeze rollers," which control the amount of wax to be left on the paper. It then passes through smoothing rollers and into a chiller, where the wax film is rapidly solidified. The speed at which the machine operates is extremely important. Surface-waxing machinery operates at high speeds, so that squeezing and chilling take place before the molten wax has been absorbed into the paper web. A different procedure is adopted when " dry waxed " paper is being produced. Here the wax is retained in molten form by passage of the strip between hot rollers, so that absorption into the paper may take place.

The chilling apparatus commonly employed also falls into two main types, using cold-water immersion in one case and passage over chilled rollers in the other. Where water chilling is used, it is necessary to remove any water which may adhere to the surface on leaving the bath. This may be accomplished by air-suction gates, as shown in Fig. 2, or by passing the paper in light contact over polished metal doctor blades.

In general, rapid chilling produces opaque coatings with high gloss. Impregnation produces translucent papers without pronounced gloss. The finished paper may contain up to about 40 per cent. of its total weight in wax.

Cartons for liquids are made up into their finished shape before waxing. The waxing may be done by total immersion in molten wax, or by simultaneous spraying outside and inside, or, if desired, on the inside only, as the cartons pass the wax jets on a conveyor. After waxing, the cartons are chilled in a refrigerating compartment, or by dipping in cold water, followed by draining and drying.

As a general rule, only refined grades of paraffin wax, with very low oil contents, are satisfactory for paper waxing. The presence of oil, or inadequate refining, leads to deficiencies such as low sealing strength, flaking, poor gloss, colour- and odour-instability, and " blocking " (*i.e.*, tendency of the waxed surfaces to adhere and flow together when the paper is stacked or rolled).

(3) *Polishes.*

Paraffin wax is widely used in the manufacture of polishes. Wax polishes for various purposes consist of pastes, creams, or emulsions of a wax composition in a suitable liquid medium.

A paste of paraffin wax in white spirit or turpentine prepared by cooling a hot solution of the wax is not satisfactory as a polishing material. The lustre obtainable is not high, the film is soft and smears easily, the solvent is only loosely held and squeezes out readily, and the paste itself dries out too rapidly. Best results from all points of view are obtained by using blends of paraffin wax with other waxes, notably carnauba, candelilla, beeswax, and ozokerite or petroleum ceresin. In the finished compositions, the function of the hard waxes is to confer lustre and non-smearing properties to the surface; that of the paraffin wax is to plasticize the hard waxes, thus giving the surface good rubbing properties. The paraffin wax also plays its part in giving suitable " body " and structure to the paste, so that evaporation of solvent does not take place too rapidly in the tin, nor too slowly on the surface to be polished.

In the manufacture of paste polishes the waxes are melted together and run into a mixer, where they are blended with the solvent, which is normally white spirit, with or without a proportion of turpentine, to which the appropriate dye or colour is added. The mixture is fed to the filling machine after its temperature has been suitably adjusted to give the required consistency. The tins or containers are passed to the machine on trays or on a conveyor belt. Alternatively, the machine may be run on rails over the laid-out tins. Delivery into the tins may be controlled automatically or by hand. The filled tins are cooled in air, or by passage through a cooling compartment, after which they are lidded and packed.

Liquid or solid creams are made by emulsifying a wax-solvent mixture with water. The emulsion may be of water-in-oil type or of oil-in-water type, according to the emulsifier used and the proportions of the phases.

A further type, widely used in America, popularly known as "dry bright," consists of a purely aqueous colloidal solution of wax and shellac.

(4) *Other Applications of Paraffin Wax and Scales.*

In the manufacture of matches, a low-melting paraffin wax (about 105–108° F.) is used to impregnate the matchsticks to assist their kindling and burning.

Various electrical appliances and equipment, such as condensers and cables, may incorporate paraffin wax or waxed paper as dielectric or insulator.

A number of chemical manufacturing processes make use of paraffin wax as a starting material. On oxidation it yields fatty acids, from which it is possible to prepare alcohols and synthetic fats. Chlorinated paraffin waxes find a number of applications—for example, as plasticizers for synthetic rubbers, as fireproofing agents, etc.

The impermeability of wax films to air, moisture, and bacteria underlies the use of wax for the preservative coating of fruit, vegetables, eggs, cheeses, hams, and other perishable goods.

In the Eastern world considerable quantities of paraffin wax were used in making brightly-coloured Batik cloths. The cloths are dyed in successive baths of colour with appropriate parts of the pattern blanked off at each stage by impregnation with wax. The wax is removed in boiling water between each dyeing stage, and the cloth then re-waxed with a new section of the pattern exposed for the next colour.

In the textile world, paraffin-wax rings are used to lubricate threads before spinning. Wax emulsions are also applied to fabrics to assist calendering after they are laundered. Paraffin-wax solutions are used in the production of waterproof and showerproof fabrics.

In the large-scale production of poultry for table use, the birds are plucked and stubbed by dipping in molten paraffin wax, then stripping the wax off whilst it is still warm and plastic. The feathers and stubs are removed with the wax.

As a fusible structural material, paraffin wax finds application in mounting and strengthening museum and art objects, and in the manufacture of crayons, coloured pencils, plaster statuettes, and modelling compositions.

Minor surgical applications include its use in plastic surgery for filling cavities and reshaping deformities and injuries—*e.g.*, to the nasal bones. Molten wax is also used as a medium for applying heat treatment for rheumatism and other ailments.

Scale wax is used in a number of minor applications, such as leather dressing, manufacture of fire-lighters, wood impregnation, barrel waxing, and so on.

2. The Petrolatum Group.

General Properties.

The waxy materials included in the petrolatum group are derived mainly from residues. Their congealing points range from about 100° to 180° F., and in consistency they vary from salve-like to firm and plastic. They exhibit crystalline structure, but the crystal size is nearly always less than that of paraffin waxes. Petrolatums are subdivided, on the basis of oil content, into the two classes: (1) *Petrolatum Wax*, which is substantially oil-free petrolatum, and is a plastic solid possessing some degree of tackiness. The congealing point is generally below 190° F., and is often indistinct; (2) *Petroleum Jelly* (Petrolatum), which is a soft, salve-like petrolatum consisting of petrolatum wax together with a substantial proportion of oil.

Petrolatum Wax

The plastic consistency of petrolatum wax, combined with its inert nature, makes it suitable for a number of special applications, such as the impregnation of insulating tapes and cable-core wrappings. It is also used to some extent for the preservative coating of cheeses, hams, and other perishable foodstuffs. Some of the firm, high-melting grades have found useful applications in paper-coating and in polish manufacture, where their plasticizing properties are useful in giving flexibility to the harder waxes and, in the case of polishes, in assisting the plastic flow of the film which gives rise to good " rubbing " properties.

The adhesion of petrolatum wax to metal and other surfaces is good, and this type of wax is sometimes used for coating the interiors of metal cans and drums for liquids. Drums for rubber latex and the metal retail " beer cans " used in the United States are frequently treated in this way.

Petroleum Jelly.

Petroleum jelly finds application as a special lubricant, both alone and as a component of greases. Considerable quantities are used for impregnating the hemp cores of wire ropes and hawsers. It is used as a component of some explosive compositions and as a plasticizer for bituminous roofing materials. Many anti-rusting and anti-corrosion compositions contain petroleum jelly. Modelling compositions of the Plasticine type may also incorporate petroleum jelly, whilst the highly refined material is widely used as a base for a number of pharmaceutical and toilet preparations.

3. The Petroleum Ceresin Group.

General Properties.

Petroleum ceresins are hard, brittle waxes, usually derived from residues, and essentially free from oil. The congealing point is usually above 160° F. (71° C.), and may be as high as 205° F. (95° C.). Petroleum ceresins are crystalline, but the characteristic crystal size is very much smaller than that of paraffin wax. The colour may range from dark brown to white, with yellow and orange perhaps most common.

A notable characteristic of petroleum ceresins (as also of ozokerite ceresin) is that a small proportion (0·5 per cent.) of the ceresin in paraffin wax may have the effect of greatly reducing the crystal size of the paraffin wax, with an attendant improvement in impermeability and in mechanical properties. Hot solutions of paraffin waxes which have been "doped" in this way may form smooth, creamy pastes on cooling, instead of crystalline aggregates.

Applications.

In general, the applications of petroleum ceresins are based upon its inertness, high congealing point, micro-crystalline structure, and its power of conferring this micro-crystalline structure on paraffin wax. Thus waxes for electrical insulating and dielectric purposes frequently incorporate petroleum ceresin. It is also used in the formulation of polishes and of pharmaceutical and other pastes and creams.

SOME IDEAS ABOUT CORRELATION OF TEST-ENGINE RESULTS.

By T. P. Sands, C. J. Livingstone, and W. A. Gruse *

The idea of correlation implies the need for a simple apparatus to find out what a more complicated one will do, and that introduces the concept of the prototype unit. In the field of engines, the procedure could be used to try out mechanical design, fuel, or oil. When mechanical construction is under scrutiny, a test will be simpler only if it is made simpler, and it can easily be more complicated. If all the mechanical parts of an engine are to be tried out together, then the best procedure is to run the whole engine; if, however, one feature is to be examined and changed at a time—say valve action as affected by cam shape and position—that portion of the working system can be isolated and studied as a unit. All the conditions which are important can be controlled and an answer written down. As a matter of fact, it would probably not be done that way, but in principle, at least, it *could* be done. If fuel is to be examined in some aspect or other, we can make simplifying assumptions, and examine the one feature of interest, whatever it may be. Actually, as soon as engines were developed far enough to be critical as to fuel, the engineers found it very much simpler to use a small and rather elementary engine in which the fuel burning could be surrounded by a controlled environment. We made our first modified Delco knock-testing engine in 1923, and the progress of twenty years has brought to a good state of development the C.F.R. gasoline and diesel engines. The problems of measuring fuel-rating numbers have been simplified and standardized very successfully. But about ten years ago we found that the problem had been over-simplified and that there were too many kinds of service which did not correlate with one kind of octane number. So now we have Research and Motor, 1C and 3C, rich and lean, and perhaps soon we may have other kinds of fuel ratings. This history of fuel-testing units and scales supplies a good example of how correlation between full-scale and small units can go astray.

In testing lubricating oil, the justification for simplified apparatus rises from the very large number of different engine types in use, from the implicit recognition that some common factors in all of them are influencing the way the oil fails, and from the further recognition that small and uncontrolled variations in these fundamental factors will influence the conduct of an oil from one engine type to another.

It is an old story that oil in engines can be spoiled by contamination (dirt, water, blowby gases) and by chemical change. We can forget about contamination, although in special cases it, too, can be studied by prototype methods. We are concerned with chemical change, and that is straight up the alley of testing with simplified engines. The changes are confined

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* Gulf Research and Development Company and Mellon Institute of Industrial Research, Pittsburg, Pennsylvania.

pretty much to oxidation and thermal cracking. Since oxidized products crack more easily and cracked products oxidize more easily, the two are tied closely together. The important factors in chemical change are time, temperature, concentration, and contact, and if one is to do a good job of theorizing on the subject, each influence must be factored out. Temperature and time, for instance, are not just crankcase temperature and change period, but the weighted sum of the time–temperature functions for oil in the crankcase, at piston-under-crown, in the ring belt, and so on. By and large from one engine to another, the extremes of all the fundamental variables are of about the same order of magnitude—that is, the range from flame temperature to outside air temperature, the time oil spends in the various parts of an engine, and the degree of mixing of air, blowby gases, and oil are not too different. Therefore, we can reason about the typical case and not be far wrong, even though we know that oil does not go to pieces in a big stationary diesel over a long time, and may yet be ruined completely in a small automotive gasoline engine in 36 hours.

To mean anything, correlation must be discussed in terms of the tests and units people are trying to correlate with at present. As a result of a whole set of influences, including the efforts of individual engine-builders to lubricate their own output and the pressure of the war emergency in the direction of setting up specifications for universal-type oils, we have three widely used tests or sets of tests. These are :

A. The 36-*Hour Chevrolet Test.*—Thanks to a good deal of co-operative effort and some careful analysis, this test has been about as well standardized as could be expected for a multi-cylinder production engine. Crankcase oil is kept at 280° F., speed is equivalent to 60 m.p.h., and power output is set to correspond to road load. Considering the general design features of the Chevrolet engine, this test can be regarded as one involving some acceleration of normal oil deterioration.

B. General Motors Diesel 500-*Hour Test.*—This procedure involves operating a Series 71 G.M. diesel engine for 500 hours under full load at 2000 r.p.m. and without oil change. The temperatures of the intake air, fuel oil, crankcase oil, and jacket water are closely controlled. Samples of the crankcase oil are taken at intervals throughout the test and examined for deterioration. The engine is dismantled and the parts are examined for varnish and sludge deposit ; copper-lead bearing shells are weighed to estimate corrosion.

C. Caterpillar Tests.—Three tests are ordinarily made :

1. *The* 480-*Hour Endurance Test.*—A single-cylinder Caterpillar test engine is operated for 480 hours at 1000 r.p.m. and a specified B.M.E.P. (75 lb.). The jacket temperature is 180° F. and the oil temperature 150° F. The oil is changed every 120 hours. The engine parts are inspected for stuck rings, scratching, or cutting at the piston top, and deposits on the piston skirt ; wear on piston and liner are determined by measuring.

2. *Run-In and High-Load Tests.*—The same engine is provided with a special precombustion chamber which directs the fuel flame against the cylinder wall at three points. Power output

is determined at a definite fuel rate, and three runs, of 3½ hours each, are made; the oil and piston are changed and the engine flushed between runs. The piston and liner are inspected for scratching or wear.

3. 120-*Hour Test; Hot-Box Test.*—A four-cylinder Caterpillar engine, set in a hot room, is operated for 120 hours. The conditions include temperature of oil to bearings 212° F. and exit-water temperature 200°. The output is about 37 B.H.P. at 1400 r.p.m. Two connecting-rod bearings are babbitt and two are copper-lead. The latter are inspected for corrosion or scratching, and the liners and pistons are rated for deposits.

From the standpoint of wider usefulness, there is one feature of several of these tests which can be criticized. It is the pass-or-fail interpretation of results; and oil is either satisfactory or not; it either corrodes or does not corrode bearings in the Chevrolet test, corrosion being defined in exact terms. It either passes or does not pass the Caterpillar and 500-hour tests. The utmost in gradation on results is found in the borderline cases. This is no doubt the right thing to do for the war emergency, but it appears to fail when regarded as the basis for a rational correlation scheme.

The desire for correlation is based on the need for definite hooking up of an accelerated test of some kind with "average service," so that in the ideal procedure 5 hours of an accelerated test would produce, say, 50 hours of average service, 10 hours of test, 100 hours of average service, and so on. There are two difficulties about this. Pass-or-fail tests, such as we have to-day, must first be converted into graded results. An oil must make a grade of 5, 10, etc. The other difficulty is in setting the factor which will convert the results to average-service figures, and here we at once run into the obstacle that there is no such thing as average service by the ordinary definitions. Service must include all the engine troubles, bearing corrosion, ring sticking, sludge separation, and so on, and as soon as one of these becomes evident in a job, the service is no longer average, again by the ordinary definitions. Most of us, subconsciously at any rate, consider average service to be light passenger-car use, but this can hardly be defended, because that kind of running really does not involve failures of any kind. Coming closer home, average service may mean a combination of the most extreme conditions encountered in each of the several heavily loaded units on the market. In terms of the oil tests used to-day, it means just that. A sober second thought will tell us that average service, even for heavy-duty units, cannot mean the above, except for war operations. For the latter, oil must be made better than the average necessity. In the accepted logic of the emergency, an oil must meet all the service conditions of all the kinds of units, because the loss of one vehicle could, in theory at any rate, have a large influence on the course of a military action.

However logical this mode of thinking is for war, it may not be the wisest in adopting a permanent way of evaluating lubricants in peace-time. When war is done, the basic considerations of overall cost reassert themselves, and the ideal becomes the greatest good for the greatest number at the smallest total expenditure of goods and labour. According to this ideal, it may be best to undergo one failure of one eccentric freight transport truck so that 999 others may operate at maximum efficiency for the longest time. This statement is based on the idea that a product which functions satisfactorily under the most severe conditions of all the current units, very probably will not, except by a happy accident, be the best oil for all, or even for more than one of them. When an oil is compounded to reach a definite value of detergency, oxidation stability, and freedom from depositing tendency, the chemist who makes it up has probably sacrificed a greater excellency in, say, wear resistance, in order to attain the detergency required, and so on. Left unrestricted to develop an oil of high detergency for a certain engine and within certain cost limits, the chemist could do much better if he did not have to remember that at the same time he must maintain a certain level of freedom from bearing corrosion because the oil is to be used in another type of engine suffering from that complaint. We know enough about oxidation inhibitors to suspect that an oil stabilized with certain types of inhibitors for the severe crankcase condition of one engine may be over-stabilized for the ring-belt conditions of another engine.

The present situation on engine testing began with the setting up by Caterpillar of a test for oils to be used in its own engines. This test served to bring out indications of several qualities, but laid particular emphasis on detergency. The object was the proving of oils which would meet Caterpillar's ideas of good service under the extreme demands on Caterpillar tractors. Following this, the General Motors laboratory defined the Chevrolet test, which, somewhat by contrast, emphasized the demand for marked oxidation stability. The oils which passed this test were intended for engines operating at very high crankcase temperature. From this it was a logical step to the General Motors 500-hour test, in which an oil was evaluated chiefly for oxidation stability, and to a smaller extent for detergency. While the Caterpillar test and its specialized successors were interpreted only for Caterpillar engines, the Chevrolet test is ordinarily considered to have a good deal of significance as indicating what will happen in General Motors diesels when the same oil is used, although complete reversals are sometimes encountered. These might be due to the presence or absence of lead, or to the differing temperature levels and conditions in the two tests.

As a matter of interpretation, and based on our temporary definition of average service, the Caterpillar 480-hour test can be regarded as not accelerated, the hot-box and scratch tests as accelerated, while the Chevrolet and General Motors tests are to some extent in the accelerated class.

At the outbreak of the war, many of the engine laboratories in the country were equipped for these three types of tests, and a fair degree of success had been attained in developing oils to meet the requirements of each separately. Two or three oils were available which met fairly well the requirements of all the tests. The war effected an immediate consolidation of requirements. The 2–104A specification was set up to define a class of lubricants which could meet all the conditions of the three outstanding tests; actually the approval was based on Caterpillar and General Motors diesel trials alone, the Chevrolet being included later to bring out the effects in gasoline engines. It was believed by those who took this step that an oil which would meet the requirements of this specification would lubricate satisfactorily all the automotive equipment of the armed forces under the most exacting conditions they were likely to encounter. The experience to date has indicated that this judgment was correct. It must be recognized that the action was an emergency step, the best that could be done at the moment. But it was not based on theory or on an adequate knowledge of correlation with service. The fact that the armed forces have not experienced any particular trouble to date does not necessarily mean that the tests mentioned actually do correlate with military service demands. It means that we now have oils which are satisfactory under all the conditions, but we do not know how far the mark may have been overshot. Furthermore, we do not know whether, perhaps, certain types of power plants might be much better off from an operating standpoint with an oil which was not quite so good when used in other types of engines. An example of this, taken from industrial practice, is found in the choice of oils for the General Motors Series 71 diesel, and the Electromotive Model 567 as used in railway locomotives. These two appear to be structurally similar, except in size, but the speed, and consequently the temperature, are higher in the former. Originally a highly refined high V.I. oil was required for the Series 71 diesel, and it is still used, properly fortified by additives. For the Model 567 in the stream-lined trains, however, the operators have, in a high percentage of cases, selected a low V.I. uncompounded naphthenic oil as most satisfactory. The use in these latter units of an oil suitable for the Series 71 engines may or may not give satisfactory operation, but would appear to add an unnecessary load from the standpoints of operator economy and national resource economy.

At the moment we seem to have an opportunity to re-evaluate the situation to see whether, in some cases, scarce and valuable additives are being used in greater amounts than are really necessary. Lacking good data on correlation of our present three test types with actual military duty, and in the absence of information on actual work under combat conditions, it appears that progress along this line must be made slowly and with extreme care. All-round dependability is at the moment more important for military duty than efficiency and economy.

The most significant aspect of this situation from a long-time standpoint comes out in the lessons which we can draw for peace-time practice. In the first place, a definition of service is in order—the kind of service with which tests must correlate. We have said above that no one should be concerned about average passenger automobile duty—at least not until passenger-car engines are made much smaller and are habitually operated at high load factor. We have in mind rather the extreme demands on heavy-duty equipment. We repeat, that for military duty on one universal type of oil, average service must be defined as the sum of all the most severe conditions to be encountered in all the types of power plants employed; aircraft oils, for several reasons, cannot be included. Average heavy-duty peace-time service, on the contrary, is not a useful concept. One type of engine may be a bad actor from the standpoint of bearing corrosion, another develops a troublesome amount of varnish deposits, a third sticks too many rings, another has a bad record on oil economy, and so on. To average all these would define a total condition which could be met by a rather mediocre oil which would not measure up satisfactorily under the typical severe running conditions of any one of the units included in the average. At the risk of being tiresome, we repeat that different units present different extreme requirements. The war-time answer is one oil good enough for all of them. But this almost certainly involves a great deal of sacrifice, justifiable only because it is a war-time answer.

The logical deduction from this—and it is an unpleasant one—is that a test must be set up for each accentuated engine trouble. That means a new engine test every time a new type of power plant comes on the market. Our laboratories would be more crowded than they are now with all sorts of test engines duplicating the conditions of every sort of obscure model.

Such an answer should not be necessary. It seems a not unreasonable hope that the development of a satisfactory prototype unit should be possible. This hypothetical engine, or its subtypes, should be flexible enough to permit operating under such conditions that a reproducible severe condition of varnishing tendency or of bearing corrosion or of wear could be set up. The general principles of that sort of manipulating are fairly well understood. The mode of operation would then be to rate oils in this engine as to detergency, oxidation stability, or wear on numerical scales; an oil would be rated 5 in detergency, 10 in oxidation stability, and so on. The engines which come on the market would be stated to have a need for 15 in oxidation stability, 5 in detergency, and so on. The analogy can be drawn with the present C.F.R. octane-rating engines; for the simpler cases we know that the octane requirements of different passenger-car engines can be stated in reasonably definite units. Of course, there are complications. Oxidation inhibitors, for instance, vary in efficiency, depending on test temperature, and detergents might do the same. An intelligent setting up of test conditions would be necessary, but the difficulty does not seem fundamental. This appears to be a rational and intelligent way out of the jungle of multiplication of test engines and one within the proper functioning of technical societies. At this stage of the situation it should be realized that tests must be developed primarily to correlate with service; exact duplication is less important than proper interpretation of results.

In passing, it seems desirable to offer one comment on the several engine tests mentioned in this paper. Within certain limits, and with very definite reservations, the Caterpillar single-cylinder engine seems to fall at least somewhere near the class of prototype units just proposed. It can remain the same, and need not be re-designed under stress of competition. Obviously, the test method will change from time to time, as field conditions change. The Chevrolet, however, a commercial power plant, is changed from year to year; several laboratories have had some little trouble in correlating results between Chevrolet models of different years. This makes it difficult to check current results with those of previous years, and it seems to us a very good reason why laboratory testing in commercial engines should not be promulgated by technical agencies. Testing in commercial engines has a definite field of usefulness; it includes the necessary transition from research to field operation, and it is definitely necessary in approval work by engine manufacturers in their own laboratories and with their own equipment. But for research and the correlation purposes discussed above, a standardized prototype seems more desirable, just as the C.F.R. is more desirable for octane numbers than a commercial Plymouth or Cadillac engine.

One final thought seems worth while. Engine tests should be divisible between those which are acceptance tests and those which are accelerated for information. It seems to us that acceptance tests should not be accelerated. The Caterpillar 480-hours is an acceptance test, it does not seem to involve more severe conditions than the oil will encounter in actual duty, and it appears to give quite reliable results—in fact, the final answer at 480 hours can often be predicted at 120 hours. The Caterpillar scratch test, however, is an accelerated one, and it does not always give the same consistent and reproducible answer. The point seems to us to be that when a test is accelerated, something more may happen than just acceleration. In theory acceleration simply speeds up what would happen if we did not accelerate. Actually, however, the ordinary ways of accelerating, such as raising the temperature, may start an entirely new tendency which did not exist at all at the lower temperature, and would never happen no matter how long the less severe condition was imposed. A simple example would be the application of an oxidation test to an oil containing a volatile additive. If the additive boils at, say, 250° F. and the normal testing temperature is 235°, then a test at 225° should be significant. But an attempt at acceleration by running the test at 275° would give an entirely misleading result. In the present state of our knowledge it seems wise to make acceptance tests under non-accelerated conditions and to reserve acceleration for information-seeking purposes only.

Mr. L. Raymond writes: "I am entirely in sympathy with the writers' plea for prototype engines to simplify and rationalize lubricant and engine testing with the different types and makes of engines. It appears to me, however, that of greater importance than the development of prototype engines is the impartial collection and analysis of performance data to serve as the basis for establishing engine-test conditions to ensure correlation of laboratory results with field performance. Without these necessary basic data, the prototype engine will lose much of its value in predicting oil behaviour. The Caterpillar Tractor Co., in its development of the Class 1 Test particularly, has done an excellent job of facilitating laboratory work and its interpretation. The strength of this test lies not so much in the design and production of the prototype engine as in the specification of test conditions which correlate with the bulk of field performance in multi-cylinder Caterpillar engines. It is not my intention to minimize the value of prototype engines, but the availability of the engine will not by itself produce the desired effect. This is illustrated by the experience with the CUE assembly, in which a standard Wright Cyclone cylinder was used originally. Difficulty in obtaining oils of known service performance as a basis for correlation greatly retarded the development of the CUE assembly as a test tool for lubricant evaluation and engine study.

On page 73 of the paper, the authors mention the operation of the prototype engine under severe conditions of varnishing, bearing corrosion, or wear, with the oils being rated numerically in detergency, oxidation stability, etc., on the basis of these tests. I question whether arbitrary ratings of oils without complete definition of the test conditions will have the desired utility. This was emphasized forcefully in our laboratory by a rather extended study of bearing-corrosion effects in a single-cylinder engine operated under a variety of test conditions with some key oils. Changes in test conditions resulted in reversals in the order of merit of the oils in this one engine. Other data obtained in other engines showed wide variability in the corrosion tendencies of oils. Some of these data have been presented and reviewed by me in a paper published in the December, 1942, *S.A.E. Journal*. Similar variations in engine results arising from differences in time of test, use of leaded or unleaded gasoline, etc., have been observed and commented upon by others.

With respect to severity of test, I strongly agree that acceptance tests should not be accelerated to the point where significance of results becomes a matter of serious concern. Tests such as the 36-Hour Chevrolet Test have the general weakness that they appear to be accelerated too much to be used with reliability in predicting or indicating the performance obtained in longer periods of operation under less severe operating conditions. Tests which are unsound, even though reproducible, have little merit. The major emphasis in the initiation of laboratory tests should be on significance of data, with subsequent attention to refinements in technique to improve precision. Too often the reverse method of attack has been the case.

I believe that the sound suggestion of the authors for the prototype engine deserves broad general support, but the inseparability of prototype engines and the basic field-performance data required for correlation must be recognized if effective utilization is to be made."

OBITUARY.

MR. J. H. C. DE BREY.

It is with deep regret that we have to announce the death, in Holland, of Mr. J. H. C. de Brey, on the 7th of October last, at the age of 63.

He was a man of outstanding ability and character. Not only did he contribute to the fundamental development of technical problems of the oil industry, but he also built up within the Royal Dutch Shell Group, from humble beginnings, a department through which he put his mark on the design of installations and plants throughout the world. Moreover, it was not only within the limits of the Shell organization that he was so well known, and there will surely be very many outside the Company who will have known him and appreciated his work.

It is not possible within the confines of this short notice to give a detailed description of his work, nor of the very wide scope of his accomplishments, but after a short outline of his life, we should like to mention some of the outstanding events in a rich and varied career.

De Brey was born in Rotterdam on the 18th November, 1880, and went to the elementary and secondary schools in that town. He then proceeded to Delft, where he obtained his degree as mechanical engineer in 1901 and electrical engineer in 1902.

From 1902 to 1906 he worked in the Caucasus on behalf of Messrs. Schuckert (as it was then) on the erection of electric power plants.

From 1906 to 1908 he worked in the Engineering Section of the Department of Public Works in Holland.

In 1908 he entered the service of the Royal Dutch Shell Group, and that same year went out to the Netherlands East Indies, where he acted as advisory engineer to the head office in Batavia. In this position he spent a great deal of his time on the oil-fields and in the refineries, and there acquired the basis of his experience for his later work.

In 1913 he returned to Europe, and after studying at first hand the oil-fields in Roumania, he went to Russia, where he was appointed Manager of the Group Company at Grozny.

In 1915 he returned to The Hague as Technical Advisor to the Board of Directors, and in the ensuing years built up the large organization which became known as the Technical Department, of which he became the head.

Whilst he spent the rest of his working days in this position, he made many trips to various places throughout the world.

Mr. de Brey was a member of various sections of the Netherlands Standardization Committee and an Honorary Vice-President of the second World Petroleum Congress, Paris, 1937. He was the founder of the Petroleum Division of the Royal Netherlands Institute of Engineers, of which division he also was the first president. Also for many years he was a member of the Institute of Petroleum.

Under the age limit imposed within the Group, he retired at the end of 1940, at the age of 60.

Owing to the occupation of the Low Countries, news since then of de

Brey has been scanty, but it is known that he suffered severely up to the time of his death.

During the five years of his stay in the N.E.I., de Brey was responsible for much original development work in connection with the recovery of natural gasoline from petroleum gases. In those days such compressor plants as were installed were used for air-lift purposes only. De Brey soon became aware of the possibilities of the benzine which could be obtained from such plants when operated on gas instead of air, and also installed field absorption plants for this purpose. The product obtained was, however, very wild and this must have directed de Brey's attention to the importance of conserving light fractions and to the necessity of stabilizing natural gasoline.

Another noteworthy achievement of his during his sojourn in the East was the development of a series of formulæ for the calculation of friction losses in oil pipe-lines. These formulæ were based on a large number of personally conducted practical experiments, and have been used in the Shell Group for a great many years. It is worthy of note that when, many years later, a new series of formulæ was developed, which took into consideration all the experimental data then available in literature, the deviation from de Brey's formulæ was remarkably small, indicating the excellence of his original experiments and their mathematical interpretation.

One of the many problems that came his way in 1917 was the design of a large pipe-line for a crude of very high viscosity. As no precedent of a mathematical treatment of the problem was known at the time, de Brey developed a method for the calculation of heated oil-lines, embodying the relation between quantity pumped, pipe diameter, and heat convection of the soil which, together with the earlier-mentioned friction formulæ, enabled him to predict friction losses with complete success.

His contact in the N.E.I. with gas recovery led him to search for a method for freeing natural gasoline from its most volatile unstable fractions—in other words, to stabilize it.

De Brey took out a patent on a pressure rectification apparatus, the stabilizer. Although in the U.S.A. the patent was not upheld, it is certain that de Brey's work gave a strong impetus to the general acceptance of the principle of stabilization, without which no refinery or gas-plant could now be imagined. The first pressure stabilizer in the Shell Group—and possibly in the world—was taken into operation in the N.E.I. around 1922.

A further development in the treatment of gases was the deep cooling of compressed gases, by expander engines, introduced in 1925, and by ammonia cooling.

Another innovation was the introduction of silica gel as a drying agent for natural gas, in conjunction with the above-mentioned installations.

The calculation and application of stabilizers gave rise to a more intensive study of close fractionation in general, which was influential in introducing better fractionation throughout the various refining centres in the Shell Group.

The keen realization of the importance of conserving the products—once produced—led de Brey to the study of the storage of light hydrocarbons, and the development of pressure storage, in order to reduce breathing losses of tanks, combined with gasometers and compressor plants for the recovery of tank gases.

Another field in which de Brey did pioneering work was that of electrical dehydration. His assistance was invited during 1923, in connection with a field producing large quantities of a very stubborn crude-oil emulsion of high salt content, which had withstood all attempts at electrical or other treatment.

By means of a non-sinusoidal alternating current with a high peak-voltage relative to the mean voltage, developed specially for the purpose, de Brey successfully solved the problem and made the continuance of the oil-field in question possible as a commercial proposition.

He extended his work, in so far that he succeeded in reducing the residual salt content of the crude in question by a process embodying re-emulsification with fresh water and re-separation by electrical treatment. This principle, which was applied for the first time in 1926, had several years later gained much prominence in various parts of the world.

De Brey always had a clear vision of the manifold problems which presented themselves in the petroleum industry, and even in fields outside his own he possessed a remarkable gift for penetrating to the root of the question. Allied to this, his keen awareness of the necessity for research and of the importance of science in connection with a young industry like the petroleum industry, has, among others, borne fruit in the establishing of a special physical section of his department and of the "Proefstation Delft," a laboratory set up for the study of the practical application of oil products in engines, burners, etc.

Through his enthusiasm and clear conception of the meaning of research he was able to attract the right men to assist him in his task, and one need only mention names like those of Prof. Dr. W. J. D. van Dijck, the late G. D. Boerlage, and J. J. Broeze, to indicate the type of collaborator who, under de Brey's inspiring guidance, became known far outside their own organizations.

Besides his considerable technical abilities, de Brey also possessed the gift of conveying his ideas to others, which, together with his excellent mastery of languages, made him a valuable contributor at meetings and discussions in this country as well as others.

His numerous friends and acquaintances will be sorry to hear of his death, which occurred so soon after he severed his active connection with the Shell Group at the end of 1940, and which was certainly hastened by the conditions imposed by the occupation of his country.

His closer collaborators, and all those who have worked under his direction, will most vividly remember his energetic mentality and his remarkable ability for inspiring enthusiasm for the scientific development of our industry, which, combined with his gift for infusing a spirit of collaboration and team-work, made working with de Brey an experience not easily forgotten.

A. E. D.
J. K.
H. H. R.
M. L. K.

ABSTRACTS.

AUTHOR INDEX.

The numbers refer to the Abstract Number.

The original papers referred to in the abstracts marked with an asterisk may be borrowed by Members from the Institute Library.

Geology and Development.

307.* Our Future Oil Supply. J. E. Brantly. *Petrol. Engr*, October 1943, **15** (1), 71.—It is essential to preserve and conserve the U.S.A. oil resources, for the annual consumption is 1,500,000,000 brl., and the known reserve is of the order of 20,000,000,000 brl.

The Drake well was drilled in 1859, and until then the oil supply available had been insufficient to warrant the creation of an industry around it. In 1903 100,000,000 brl. was produced for the first time. The production was trebled by 1916, a few years after the gasoline engine became widely available. In 1916 the reserve was estimated to be 4,000,000,000 brl. 1,000,000,000 brl. was produced in 1929, the reserves being estimated at 10,000,000,000 brl. During the ensuing depression the oil output fell. It again exceeded 1,000,000,000 brl. in 1936. In 1940 1,350,000,000 brl. was drawn from reserves estimated at 18,500,000,000 brl.

Since 1859 28,000,000,000 brl. of oil is estimated to have been produced. About 1,075,000 wells have been drilled, 740,000 producing oil, 100,000 producing gas, and the rest being dry. About 400,000 wells are still producing.

The present production of nearly 4,400,000 brl./day is within 200,000 brl./day of the maximum production possible without damaging the producing potentialities of the fields. It is likely that within a few years' time the U.S.A. oil requirements will be 6,000,000 brl./day.

The greatest potential oil-bearing region of North America remaining to be fully explored and developed is the belt of country embracing the western part of the Central Continental Valley, running from the Arctic Ocean off the Mackenzie River Basin south-east to Mexico. Permian to Cretaceous, as well as older Palæozoic formations produce oil in this belt, and many oil-fields are known from Fort Norman to Poza Rica. There are other areas with possibilities, such as Alaska, British Columbia, Washington, Oregon, Northern California, the St. Lawrence Basin, the Atlantic and Gulf Coast plains. In spite of the probable potentialities of these and of the developed regions, it is by no means certain that the U.S.A. needs can be met for a considerable number of years.

Before the oil industry is driven to use the costlier synthetics, oil will be drawn from foreign sources as far as possible. At present the world consumption is over 2,000,000,000 brl./year, and after the war ends it may soon attain 3,000,000,000 brl./year. Even if the rest of the world has reserves greater than those of North America, much time and effort will be needed to develop them, and much of the burden will fall on Americans. Except for Russia and U.S.A., the oil-producing countries have not developed industrial and manufacturing economies, and they must trade their oil, other minerals, or agricultural products for manufactured goods. The development of the oil and its distribution must go on under equitable conditions.

Mexico and many of the countries of Central and South America have excellent fields and also considerable undeveloped oil possibilities, and it is towards these that U.S.A. must look to meet the deficiencies which may soon develop in its own productive capacity. G. D. H.

308.* Drilling Activity in South Dakota. Anon. *Petrol. Engr*, October 1943, **15** (1), 134.—A gas-flow of 86,000 cu. ft./day accompanied by 1700 brl./day of water has been obtained in a deep test in Potter County, South Dakota. The well proves the existence of a structure of considerable size, and was drilled to the Dakota sands.

The Harding County wildcat is intended to go to a depth of 7900 ft., but drilling is temporarily suspended at 6466 ft. A second oil-test is being drilled slowly in Aurora County, while a third is under way in Fall River County, near Ardmore.

A gas-well is being drilled at Pierre.

Several million acres of land are under lease in North and South Dakota. This year heavy leasing has been reported in Harding County. New leasing terms have recently been established in South Dakota. G. D. H.

309.* Current Status of Mexico's Petroleum Industry. J. J. March. *Petrol. Engr*, October 1943, **15** (1), 198.—Since nationalization in March 1938, the Mexican oil industry has been operated by Petroleos Mexicanos, employing an almost entirely Mexican personnel. The production rose from 1938 to 1940, and declined afterwards, largely because of the loss of foreign markets. The decline does not signify a decline in productive capacity. Development in the last five years and a comprehensive survey of the reserves point to a total reserve of 750,000,000 brl., about twenty times the average production since 1938.

Efforts have been made to conserve the known reserves and to exploit them in accordance with the best technical practices. Special studies have been made at Poza Rica, the most important field, and there it seems advisable to limit the production in order to conserve gas and to prolong the life of the field.

In the last five years 54 producers have been completed out of the 91 wells drilled in the various fields. 54 wells are planned for 1943, in the known fields, and in new areas such as to the west of " Faja de Oro," Chicontepec and south of Poza Rica, to the Sierra Madre Oriental mountain range, and in Tabasco; on the Pacific side, in Lower California, Sonora, and Sinaloa, and in the north-east of Mexico in the states of Nuevo Leon and Tamaulipas.

Improvements, replacements, and additions of new equipment have been made to the several refineries in Mexico, increasing their efficiency and capacity. The pipe-line from Poza Rica to Atzcapotzalco has been increased in capacity from 15,000 brl. to 22,500 brl./day, and that from Poza Rica to Tampico from 40,000 brl. to 63,000 brl./day. The number of rail tank-cars has been nearly doubled since 1938 and there has been a substantial increase in the number of motor tank-cars. In spite of losses, the tanker capacity has risen from 17,500 tons to 84,000 tons, and a further 53,250 tons is operated exclusively by the oil industry.

The total storage capacity of bulk plants has been increased from 58,952,000 to 72,493,000 gal., and a large new distributing terminal has recently been erected at Salina Cruz to supply the West Coast needs.

The annual volume of domestic sales of Mexican petroleum products has risen continuously in the last five years, the prices being at pre-nationalization levels in most cases. Export sales have fluctuated, and have fallen substantially since 1940.

In 1942 the federal taxes paid by Petroleos Mexicanos amounted to 80,000,000 pesos, 27,000,000 pesos more than was paid in any year by companies operating before 1938. The salaries and wages of the personnel have been raised, making them the best-paid of any labour group in Mexico. Personnel have also received other benefits. G. D. H.

310.* Drilling Increases Sharply in September; Wildcatting Off. Anon. *Oil Gas J.*, 21.10.43, **42** (24), 106.—1827 wells were completed in U.S.A. in September, a greater number than in any month since January 1942. 958 gave oil, a number last exceeded in February 1942. The 675 dry holes were the highest number recorded in any month since July 1941, when 3165 wells were completed.

The ratio of dry holes to producers was abnormally high, and in order to complete the normal number of oil-wells an 80% increase in drilling would be necessary.

The average initial production of the wells completed in the middle of 1941 was about 330 brl./day, whereas now it is about 190 brl./day.

In September 129 more oil-wells were completed than in August, and of the increase 93 were in Texas. During the first nine months of 1943, 289 wildcats found oil, and 117 found gas or distillate. However, the total new oil found was less than in previous years. The most important discoveries in 1943 have been in the Lower Cretaceous of East Texas and Wyoming, while the most important new pay found has been in the Ellenburger of Winkler County, Texas.

In the third quarter of 1943, 1012 wildcats were drilled, an average of 337 per month, compared with an average of 225 per month in the first half of the year.

A table summarizes by States and districts the results of drilling in September 1943, while a second table analyses the wildcat completions by months in the period July–September. G. D. H.

311.* Wildcats and Discoveries. Anon. *Oil Gas J.*, 21.10.43, **42** (24), 132.—In the week ended 16th October, 1943, 76 wildcats were completed in U.S.A., seven fewer than in the previous week. The discovery well of the Chitwood pool, Pratt County, Kansas, was completed in the Simpson sand. It lies on a well-defined trend extending into the Dodge City Basin. Along the same trend are the Cairo gas-field, and the Cunningham, Lerado, and Bear Creek pools.

In Illinois extensions were made to the Albion, East Albion, and Mount Carmel pools in the Wabash River area. Near Epworth in White County, a 7-brl. well was completed in the McClosky. The two gas discoveries in Oklahoma may prove to be extensions, one being in the newly-discovered Elgin area in Comanche County, and the other north-west of the Cruce pool in Stephens County. Both produce from shallow Pennsylvanian sands. The Hildreth pool of Montague County, North Texas, has been extended, and an outpost of the Eliasville field of Stephens County has found Mississippi lime production. A 10-brl. shallow pumper was brought in in Pecos County, West Texas.

The results of wildcatting are summarized by States and districts for the week ended 16th October, with cumulative totals for 1943 up to that date. G. D. H.

312.* Availability of World Oil Supply. E. O. Thompson. *Oil Gas J.*, 28.10.43, **42** (25), 39.—It is estimated by the P.I.W.C. that even with strict rationing there will be a shortage of oil in U.S.A. amounting to 500,000 brl./day in the third quarter of 1944. The present producing rate of 4,600,000 brl./day is a record, yet the above-ground stocks of oil and products have gradually fallen to the absolute minimum for safety. In order to maintain this high rate of production, a new 30,000,000-brl. field should be brought in every six days.

A fair oil price has been denied, and this has kept down exploration and drilling. An 8·4% increase in price, as allowed in other industries, would permit a 35-cent-a-barrel rise in price, and it is believed that this would immediately lead to a 50% increase in drilling. A 52% rise occurred in California when the oil price was increased by 35 cents per barrel.

The low price affects the stripper-well operator most seriously. He cannot afford to spend money on secondary recovery methods in order to increase his production.

It is farther from Houston to New York than from Aruba to New York.

In Bahrein, Egypt, India, Iran, Iraq, Saudi Arabia, Trinidad, and the United Kingdom the potential is about 845,000 brl./day, while the current production is only 423,000 brl./day.

In 1942 the world oil reserves were estimated to be 54,882,600,000 brl., U.S.A. possessing 20,000,000,000 brl.

Efforts are being made to produce and refine oil nearer to the places where it is being used by the fighting forces. G. D. H.

313.* Oil-Zones of the United States: Miocene-Pliocene. Anon. *Oil Gas J.*, 28.10.43, **42** (25), 63-C.—The lowest pay in the eastern half of the San Joaquin Valley is the Vedder sand of the Vaqueros (Lower Miocene), which produces at a depth of over 10,000 ft. in some fields. The Temblor of the Middle Miocene is the principal pay at Kettleman Hills and in some of the newly discovered fields north of Coalinga. In the central part of the basin the Stevens zone (Upper Miocene) is productive. Pliocene production is limited to the edges of the basin, oil coming from the Charnac zones of the Etchegoin, the Jacalitos, and the Kern River zones of the San Joaquin clay.

The Monterey is the principal producing zone in the Santa Maria district, and together with the Pliocene produces in the Santa Barbara district of the coastal sector. All production in the Ventura district is from the Pico and Repetto (Pliocene). The Modelo (Upper Miocene) is the main producing horizon in the Ventura–Newhall district, in which the Pico and Repetto also produce. The Pliocene and Upper Miocene produce in the Los Angeles Basin, and a small amount of oil is obtained from the top of the schist.

Many lensing pays occur in the Miocene of the Gulf Coast, and a few fields produce from the Pliocene. In the Miocene there is a general rise in the age of the uppermost pays from west to east.

Deeper drilling in the San Joaquin Valley and the coastal district of California is expected to give additional Miocene and Pliocene pays. Since production in South-east Louisiana does not extend much north of Lake Pontchartrain, the best chances of Miocene and Pliocene production farther east are offshore along the coastal shelf.

From the Upper Cretaceous to the Pliocene the formations are valley and basin fill, the geological history of the areas consisting of a series of sea advances and retreats with numerous small unconformities and some continental deposits. These increase in volume in the upper part of the section in any district. Thus the areas contain many wedge-edges and erosional traps.

A map shows the Miocene–Pliocene outcrops, and the oil-producing, favourable and unfavourable areas. G. D. H.

314.* Oil Discovery in South-western Florida Starts Lease Play of Major Proportions. Anon. *Oil Gas J.*, 28.10.43, **42** (25), 86.—Oil production has been found at a depth of 11,700 ft. in a well near Sunniland, Collier County, Florida. It is over 500 ml. from the nearest producing field. 500–600 brl. of 20° A.P.I. oil has been swabbed from the well, and a fair volume of gas is present. The salt-water encountered is believed to come from behind the casing.

The first 6000 ft. of hole was drilled through highly porous dolomitic limestone in which the maintenance of circulation was difficult. The well probably cost $300,000. Considerable acreages have been leased around the well and elsewhere in Florida.

G. D. H.

315.* Wildcats and Discoveries. Anon. *Oil Gas J.*, 28.10.43, **42** (25), 100.—In the week ended 23rd October, nine wildcats gave oil and one gas in U.S.A. There were 52 dry wildcats. The most interesting discovery is the Helis well south-east of Devers and north of the Hamkamer field, Liberty County, Texas. The Yegua is productive, although it is dry at Hamkamer. 4 ml. from Hull-Silk, Archer County, North Texas, a new Ellenburger producing area has been opened. Five small discoveries have been made in Illinois, two being extensions to the Plainview and Rinard pools. A Devonian pool was opened in Madison County, a McClosky well south-east of the Kell pool in Jefferson County, and a small pumper in northern Clay County. A discovery was made in Union County, Kentucky, and a small pumper was completed in Enterprise Township, Missaukee County, Michigan. East of the old Ingalls field a gas well was completed in Payne County, Oklahoma.

The wildcat completions in the week ended 23rd October, 1943, are summarized by States and districts. G. D. H.

316. Deeper Drilling Prospects in the Mid-Continent. A. R. Denison. *Petrol. Tech.*, November 1943, **6** (6), A.I.M.M.E. Tech. Pub. No. 1650, 1–8.—Examination of the Northern Mid-Continent area, Seminole District, East Texas Basin, Texas Gulf Coast region and the Permian Basin of West Texas and New Mexico shows that there is 5000–10,000 ft. of sediments underlying several hundred square miles of oil-producing structural traps. Hence on many of the best structures some hundreds of cubic miles of sediments await exploration by drilling, and in many places the thickness of sediments to be explored is greater than the thickness already exploited. The recent outstanding success of deeper prospecting in West Texas shows the merits of deeper drilling on known structures.

In the above structures there is no need for geological or geophysical effort, since structural control is available from the wells already drilled. On many structures the test wells need not exceed 10,000 ft. in depth, and on none 15,000 ft. They all have the great advantage, in these times of material shortages, of having pipe-line and transportation facilities already available, and in many places there is no need for much additional man-power.

With these factors in its favour it appears that the quickest and most certain method of alleviating the present danger of a shortage of "capacity to produce" is deeper drilling on known, proven, productive, structural traps. G. D. H.

317.* Hildreth Field's Performance Raises Appraisals on Caddo Conglomerate Pay. H. F. Simons, *Oil Gas J.*, 18.11.43, **42** (28), 18.—The Hildreth pool of Montague County, Texas, produces from the Caddo (Bend) conglomerate. The first well was completed in the Ellenburger at 7170–7201 ft., and gave 329 brl./day initially. Recently this well was perforated opposite the Caddo conglomerate, drill-stem tests during the drilling having shown some free oil. In the second well this pay was tested at 5990–5996 ft. and 6065–6109 ft., and gave a potential of 4515 brl./day. Five conglomerate producers have been completed, and a recent completion has shown four pay-zones in the conglomerate, each zone giving a potential of well over 1000 brl./day on test.

The average position of the top of the Caddo is at −4969 ft. (sub-sea-level), with the pay-zones some distance below the top of the formation.

The Ellenburger has not been adequately tested in any but the discovery well, although all the wells are suitable for deepening to this horizon if required.

G. D. H.

318.* Wildcats and Discoveries. Anon. *Oil Gas J.*, 18.11.43, **42** (28), 83.—In the week ended 13th November, 1943, 81 wildcats were completed in U.S.A. Nine gave oil and four gave gas. In McPherson County, Kansas, Mississippian chat production was extended about 3 ml. south of the Roxbury and Crowther pools, by a 400-brl. well, which has dry holes within ½ ml. to the east and west. A 150-brl. well has extended the Dubuque pool south-west in Russell County, Kansas.

An open-flow test gave 50,000,000 cu. ft./day in a gas discovery in the Travis Peak at 5876–5896 ft. in Lincoln Parish, North Louisiana. The well lies 2 ml. north-west of the old Ruston gas-pool.

The results of wildcat completions in the week ended 13th November are summarized by States and districts. G. D. H.

319.* More Wildcats Drilled in October but Results Far Below Requirements to Maintain Reserves. D. L. Carroll. *Oil Wkly*, 22.11.43, **111** (12), 36.—324 wildcats were completed in U.S.A. in October 1943, compared with 276 in September, but the results continued to be poor generally. Illinois had 17 successes out of 45 wildcats, Texas 17 out of 73, California 4 out of 25, and Oklahoma 5 out of 40.

2754 wildcats have been completed in U.S.A. in the first ten months of 1943, 104 more than in the same period of 1942. The total is well below the 3700 wildcats scheduled by P.A.W. for the period.

The Illinois discoveries in October comprised 13 oil-field extensions, 4 new pays, and 2 new pools, and the California discoveries 1 extension, 2 new pays, and 1 new pool; 1 new distillate field, 1 new distillate pay, and 4 new gas-fields were found in October.

The Little Kentucky field 1½ ml. south-east of the Mauritz field, Jackson County, Texas, came in at 139 brl./day from the Frio at 5700 ft. The reserve may be 4,000,000 brl. The Bateman Ranch field of King County, Texas, topped the Pennsylvanian at 3688 ft., and flowed 361 brl./day. It lies 6½ ml. east of Guthrie, and may be followed by other discoveries on the east–west trending anticline. The nearest production is 24 ml. away.

The new South Devers field of Liberty County, Upper Texas Gulf Coast, produces from the Frio below 7704 ft. Georgetown production has been found below the Woodbine at Hawkins.

The Divide pool of Jefferson County, Illinois, was opened by a 264-brl. pumper in the McClosky at 2733 ft. The Schnell pool, Richland County, has been extended ¾ ml. by a well which is within 1 ml. of the prolific Noble pool.

Huron, the new Californian field, is of doubtful value, for the area has given only spotted production from thin lenticular pay sin the Miocene. A new shallow pay has been found in the Tulare at Midway-Sunset.

In Pratt County, Kansas, a new field has been opened by a 2672-brl. well. It is on a southward branch from the Central Kansas Uplift. The pay is said to be a stratigraphic trap in the Simpson at 4399 ft. The Rangely field of Rio Blanco County, Colorado, was discovered in 1933, the discovery well being closed in. The well has now been opened. It produces from the Weber quartzite (Pennsylvanian), the 668-ft. pay being below 5657 ft. Other wells produce from the shallower Mancos shale. The structure covers nearly 100 sq. ml.

A table gives a summary of wildcatting results by States in October, with September totals for comparison.

The October discovery wells are listed, with the location, depth, producing horizon, and other information. G. D. H.

320.* New Programme of Federal Geological Survey is Streamlined to Needs of Oil Industry. H. D. Miser. *Oil Wkly*, 22.11.43, **111** (12), 40.—The U.S. Geological Survey is determined to try to obtain geological data that can be expected to lead to the exploration of new areas. The intention is to acquire and publish immediately information on the stratigraphy, palæontology, structure, changes in facies, porosity and thickness of producing zones, and the relations and extent of lenticular sands—from the point of view of a more complete understanding of regional geology. The geological data will be assembled in the form of maps, cross-sections, or notes. The determination of local features, whether by surface, subsurface, or geophysical methods, will in general receive little consideration. Congress has appropriated $300,000 to initiate the investigations and to finance them until 1st July, 1944. Parties have been organized and supervisors secured for projects under way in California, the Rocky Mountains, and Mid-Continent regions, the Gulf Coast Plain, and the Appalachian region.

In California the east edge of the Los Angeles Basin is being examined from the point of view of overlap possibilities in the Miocene and Pliocene. Similar studies are under way in the Miocene of the east Salinas Valley and adjoining areas, and in much of the Tertiary of the Santa Maria Basin.

In the Rocky Mountain region maps and stratigraphic sections are being prepared of the marine sediments of the Pennsylvanian near Pecos and Albuquerque, New Mexico, North-west New Mexico and North-east Arizona, North-west Colorado, East Colorado, and some of the structural basins of Wyoming.

The projects in the Mid-Continent and Ozark region deal with the Forest City and Salina Basins, the Arbuckle of Oklahoma and Kansas, and the Ellenburger possibilities of North Texas. In the Appalachian region the gas-producing possibilities in the Mississippian in East Ohio, Pennsylvania, and West Virginia are to be studied first. The Devonian and older rocks are to be studied at depth in Michigan.

Many of the large oil companies will release data to speed the projects and to avoid duplication of effort. G. D. H.

321.* Search for Oil and Gas Active in West Canada. Anon. *Oil Wkly*, 22.11.43, **111** (12), 49.—In October there were 9 new well locations at Vermilion, 2 at Viking, 2 at Taber, and 1 each at Lloydminster, Wrentham, Pinhorn, Pincher Creek, Grassy Lake, and Erickson Coulee. Turner Valley had 4. The test 3 ml. south of Wrentham and 35 ml. south-east of Lethbridge is in new territory, some 10 ml. from Skiff, where several wells in 1927 and 1930 found non-commercial production of heavy oil. The Pinhorn well is to the south-east. In the Taber-Chin field the Imperial-Clancey No. 2 well on the south-east extension of the Taber field is to be taken to the Madison after finding a mixture of oil and water in the so-called Taber sand.

The Grassy Lake test is 6 ml. west of the Bow Island gas-field. About twelve years ago a strong gas-flow was obtained in the Erickson Coulee area; now an oil test is to be drilled. This area is north-east of Kevin-Sunburst. In the same general area the Rogers-Imperial well had a flush gas production of 50,000,000 cu. ft./day. The old Dead House Coulee well had good oil and gas-shows.

The Red Coulee wells are still producing steadily, and at Del Bonita a well is coring porous Madison limestone at 5052 ft., and finding excellent oil and gas saturation.

A new Kinsella–Viking test is to be drilled 3½ ml. south and 4 ml. west of the dry Anglo–Kinsella test, and 9 ml. east and 10 ml. south of Imperial–Viking 2. In the Athabaska district, Deca 3 is being drilled 800 ft. east of Decal, which had a good oil sand, but was abandoned. The well is expected to find oil saturation at about 1650 ft. G. D. H.

322.* Fort Norman Production Up Sharply This Year. Anon. *Oil Wkly*, 22.11.43, **111** (12), 49.—In the first half of 1943 the Fort Norman field produced 89,929 brl. of oil, compared with 9764 brl. in the corresponding period of 1942. The above figure does not include the output of wells drilled and then capped during the construction of the pipe-line to Whitehorse. G. D. H.

323.* Development Work Spreads in Black-Oil Horizons of Big Horn Basin, Wyoming. N. Williams. *Oil Gas J.*, 25.11.43, **42** (29), 24.—Exploration and development of the "black" oil-producing horizons of the Big Horn Basin structures are spreading. The oil is typically 20–22° Bé., asphaltic base crude, coming from the Embar, Tensleep, Amsden, and Madison. Early work was in the shallower horizons which produce on some of the structures, and when the deeper "black" oil was encountered it was rarely developed extensively. The structures now being developed are around the rim of the basin and are clearly shown at the surface. There may be important reserves in buried structures within the basin.

During 1943 prolific Tensleep production has been developed in the Elk Basin field. About 6000 acres have been proved on a structure which has 1600–1700 ft. of closure. The reserve is estimated at 300,000,000 brl. 18 wells give 15,000–18,000 brl./day from depths of 4400–5300 ft. The shallow sand production covers only 1200 acres. The oil is about 30° Bé.

Embar and possibly Tensleep production have been found on the Gebo structure in the south of the Big Horn Basin. The Embar was topped at a depth of 4735 ft. The Little Buffalo Basin structure in the western part of the Big Horn Basin is large and pronounced, and has given shallow gas for many years. Two deep tests are now being drilled.

The large-scale development of the Big Horn Basin is handicapped by the lack of pipe-line outlets. Consequently a substantial volume of oil production is already shut in. Several pipe-lines are being planned.

Excluding Gebo, thirty oil- and gas-producing structures have been found in the Big Horn Basin. They have given over 82,500,000 brl. of oil, about half of it "black" oil. 17 structures give "black" oil, but only 10 are producing regularly. 47,500 brl./day of "black" oil is being produced, and it is estimated that the rate can be doubled in several months. The light oil production is about 2200 brl./day, 1575 brl./day coming from Grass Creek.

A table gives the producing fields of the Big Horn Basin, with the discovery year, cumulative production, and current production of light and black oil. G. D. H.

324.* Monthly Wildcat Completion Record, August–October, 1943. Anon. *Oil Gas J.*, 25.11.43, **42** (29), 100.—During October there was a slight increase in the total number of new oil discoveries in U.S.A., Texas having 13 compared with 6 in September. The totals for August, September, and October were respectively 56, 33, and 37 oil discoveries, 1, 5, and 1 gas discoveries, and 299, 225, and 238 dry wildcats.

In October the Chitwood pool of Pratt County, Kansas, was probably the most important discovery. The main pay is the Simpson at 4550 ft. Efforts are being made to make the wells three-zone producers. The other discoveries were extensions.

A table gives by States and districts the different types of wildcat completions for August, September, and October. G. D. H.

325. Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 25.11.43, **42** (29), 106.—In the week ended 20th November, 1943, 8 new discoveries were made in U.S.A. The best was a Viola discovery in Pottawatomie County, Oklahoma, some 2 ml. west of the Asher pools, which produce from the Viola, Simpson, and shallower sands. The well was completed for 629 brl./day through a $\frac{1}{16}$-in. choke. The top of the pay is at 4140 ft.

A 215-brl. well was completed at a depth of 10,009 ft. to open the Rosedale field in Iberville Parish, South Louisiana. The Gibson pool of Terrebonne Parish has been extended 1 ml. by a 215-brl. well. A large gas-distillate well was completed in Panola

County, East Texas. It gave 191,000,000 cu. ft. from the upper and lower Pettit lime zones.

The wildcat completions in the week ended 20th November, 1943, are tabulated by States and districts. G. D. H.

326.* Summary of October Drilling Operations. Anon. *Oil Gas J.*, 25.11.43, **42** (29), 107.—1350 development wells and 286 wildcats were completed in U.S.A. in October 1943. The four-week period gave a slightly higher completion rate than for September, and a considerably greater ratio of wildcat to development wells. Drilling activity declined a little in the Gulf Coast area and rose in West Texas and North Texas. California maintained its increased rate of completions. 25 10,000-ft. wells were completed, compared with 13 in September.

A table summarizes the October completions by States and districts, subdividing them according to type and depth, and giving totals for September. G. D. H.

327.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 2.12.43, **42** (30), 91.—In the week ended 27th November, 1943, 13 wildcats were completed as oil-wells in U.S.A. The wildcat completions totalled 82, and included 1 distillate well and 1 gas-well. A new Ellenburger pool was opened 7 ml. south-west of the Muenster pool in Cooke County, North Texas. The discovery well had an initial potential of 828 brl./day. The Murray pool of South-western Young County, North Texas, was extended 2 ml. by a Marble Falls producer, after plugging back from the Ellenburger at 4657 ft. 5 ml. west of the South Unice field the San Simon field was opened in Lea County, South-east New Mexico. Production is from limestone at 4025–4125 ft., the approximate level of the Unice production.

Of the oil discoveries 6 were in Illinois.

A table summarizes by States and districts the results of wildcat completions in U.S.A. in the week ended 27th November, 1943. G. D. H.

328.* 12,056-foot Wildcat is Deepest Canadian Test. Anon. *Oil Wkly*, 6.12.43, **42** (31).—On the Jumping Pound structure, 20 ml. west of Calgary, Shell-Norman No. 1 has stopped drilling at a depth of 12,056 ft., having penetrated 468 ft. of Madison limestone. It is in the black lime below the Lower Porous Limestone. G. D. H.

329.* Frio Discovery in Old Salt Dome Field is Major Strike. D. L. Carroll. *Oil Wkly*, 6.12.43, **112** (1), 12.—The Vinton field in Calcasieu Parish, Louisiana, was opened commercially in 1910, although small amounts of oil had been obtained from 40–50-ft. wells for many years previously. This shallow oil had probably reached sand-lenses in the Beaumont clay through faults, or because of the permeability of the underlying Fayette beds. Up to November 1942 the deeper Miocene beds were the producing horizons, and then the first Frio well was completed, opening up a series of Oligocene pays which seemed to promise reserves of the magnitude of the previous production of about 46,000,000 brl.

The Miocene produces on the east flank, and is apparently barren elsewhere, except for a small area on the north. The Frio also pinches out on the flank and is absent except on the north and possibly on the south-east.

The Frio discovery well came in at 140 brl./day from a sand with 36 ft. of oil-sand and 263 ft. of gas-sand. 14 Frio producers have been completed, and many show 5 separate pays. The pays are 4875–5781 ft. deep. This north flank production is exceptionally wide for the flank of a dome. 3 small producers have been completed on the south-east in a pay which is difficult to identify, but which may be Frio. G. D. H.

330.* Lake Erie's Best Gas Well to be Connected. Anon. *Oil Wkly*, 6.12.43, **112** (1), 48.—The West Petroleum Lake Erie well has an open flow estimated at 750,000–1,000,000 cu. ft./day of gas, after being shot. It is 1285 ft. deep. G. D. H.

331.* Production Drops to 4,400,871 brl. Anon. *Oil Wkly*, 6.12.43, **112** (1), 48.—In the week ended 4th December, the U.S.A. oil production was 4,400,871 brl./day, 27,219 brl./day less than in the previous week. Declines of 20,900 brl. and 10,300 brl./day, in Texas and California, respectively, were mainly responsible for this decrease. 7 States showed increases of 1000–3000 brl./day. G. D. H.

332.* Taber Best Canadian Field Outside Turner Valley. Anon. *Oil Wkly*, 6.12.43, **112** (1), 52.—In the first nine months of 1943, Taber, the largest producing field in Alberta outside Turner Valley, gave 64,086 brl. of oil. Vermilion produced 47,425 brl. in the same period, and the total production outside Turner Valley was 141,989 brl. Red Coulee gave 6611 brl., and Wainwright 13,575 brl. G. D. H.

333.* Mexico's Production Continues Upward. Anon. *Oil Gas J.*, 9.12.43, **42** (31), 41.—The daily average production was 105,726 brl. in September and 110,299, brl. in October, the highest rates for 18 months. The most important increases were in the North Tampico district, where the average was 19,293 brl./day in October. The Poza Rica production was 57,377 brl./day in October.

Tables give the monthly totals and daily averages each month for 1942 and 1943. G. D. H.

334.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 9.12.43, **42** (31), 106.—Only 2 oil-wells, 2 condensate wells, and 3 gas-wells were brought in in the 64 wildcat completions in U.S.A. in the week ended 4th December, 1943.

In Evangeline Parish, Louisiana Gulf Coast, the second condensate well was completed in the new Reddell pool. This well lies 1¼ ml. east of the discovery well, and found Tate sand production at 9881 ft., and Wilcox production of 358 brl./day of 58-gravity condensate at 10,494 ft.

A condensate well and a small gasser were completed in Colorado County, Texas Gulf Coast, a shallow gas-well was completed in Greer County, Oklahoma, and a Dakota gas-well in South Baxter Basin, Sweetwater County, Wyoming. This last well was plugged back from the Tensleep at 7172 ft., to give 5,000,000 cu. ft./day of gas from 2850 ft. A 95-brl. oil-well was brought in in Archer County, North Texas.

Tables summarize by States and districts the results of wildcat completions in the week ended 4th December, 1943. G. D. H.

Geophysics.

335.* Use of Fluorescent Surface Surveys and Subsurface Logs to Find Oil. T. L. Turner. *Oil Wkly*, 29.11.43, **111** (13), 22.—Since all hydrocarbon compounds are strongly fluorescent, it is possible, by suitable means, to detect their presence in soil. It is claimed that by measuring the amount of fixed hydrocarbons in the colloidal portions of the surface soil or subsurface well-cuttings productive areas can be delineated, showing faults and other subsurface data, and that by the same method with well-cuttings the possibility of production below the bit may be determined.

Soil samples are collected from a grid of points at depths of 4 ft. for preference, and sent to the laboratory, where they are dried, crushed, and de-mineralized. The residue is examined by the fluorograph, and the fluorescence is measured on a sensitive film by a densitometer, which will detect fluorescence 300 times less than the eye can see. The fluorescence values are plotted on a map. The surface sample need not exceed 1 oz. in weight.

In a well, if the highly permeable beds show positive concentration and the impermeable beds show negative concentration, the presence of an oil or gas deposit in the general area is indicated. The positive values are some clue to the distance of the deposit from the well.

Fluorologs cost about $0·03 per foot if the samples are delivered to the laboratory, while fluorographic field surveys are $3·50 for each sample, and $1·0 for each sample taken by the field crews.

Several fluorologs and a fluorographic field survey are discussed in some detail. G. D. H.

Drilling.

336.* Life of Walking Beam Rockers Extended by Hard-Facing Technique. E. Sterrett. *Oil Wkly*, 8.11.43, **111** (10), 79–80.—A procedure is described for reconditioning walking beam rockers. The cast steel, of usual foundry grade without special alloying to extend wearing qualities, was known to be readily weldable, and was built up on the low sections with mild or high-carbon steel until the original outlines were restored. Over the surfaces thus formed a single layer of hard-facing metal was applied electrically, the beads being deposited parallel to the arc of curvature in the concave bearing surface, the beads following the curve of the rocker section instead of being laid as straight lines lengthwise of the bearing area. On the cap or upper half of the rocker pair the beads were placed as straight lines across the curve of the member, so that as the unit rocked in service each bead would in turn bear the beam load. This setting of the beads at 90°, so that no high spots or grooves would tend to match, and thus to cause cramping of the rocking surfaces, insured uniform distribution of loading across the entire rebuilt faces of the units, and also made for longer life, by preventing channelling as the parts wore down to wider bearing surfaces. Details of incidental operations are given. A. H. N.

337.* Mud Acid Treatment Effective in Reworking and Completing Wells. D. L. Carroll. *Oil Wkly*, 22.11.43, **111** (12), 15–16.—Well-service experience over a period of years has demonstrated that the mudding-off of oil-pays may result from a number of different causes, but that whatever the cause, this type of oil-flow obstruction can usually be overcome by proper use of special acid mixtures. Cases of mudding during drilling, cleaning, or production from wells are given. It is emphasized that the mud in these cases cannot be removed merely by water or hydrochloric acid. Correct treatment calls for the use of special chemical fluids that can actually break down or dissolve those clay minerals comprising most of the bulk of drilling mud solids or clays present in oil-bearing strata. In field practice this theory has been applied with success, using hydrochloric acid solutions, to which have been added other chemicals or chemical agents which possess de-emulsifying and de-colloidizing properties, that also reduce the surface tension of fluid mixtures, and actually dissolve such ordinary inert clay minerals as montmorillonite, beidellite, illite, kaolin, and muscovite.

It has been proved that standard, bentonite-type drilling mud clay which has been treated for only a few minutes with an appropriate mud acid solution will filter water with comparative ease, even though only a small proportion of the clay mass has been dissolved. The effect is that of creating permeability in an impermeable substance, by taking away its colloidal or swelling properties. The same effect is produced by similarly treating actual mud-cake specimens. The acid will increase the permeability of the cake from nothing at all to a high degree, without any apparent change in the appearance of the specimen. On the basis of laboratory tests it is believed that 1 gal. of the acid mixture will break down approximately $\frac{1}{10}$ lb. of obstructing clay material. The reaction rate and the results are affected by the temperature factor, but not by pressure. At bottom-hole temperatures of around 200° the reaction time is perhaps 50% shorter than at a surface temperature of 70°. It should be noted, however, that the acid will spend itself most quickly when the ratio of clay to acid is high. In normal drilling mud treatment the mud-acid solubility is proportional to the beidellite content of the material, as shown by X-ray analyses before and after treatment. Records of treatments are given. A. H. N.

338.* Horizontal Wells May Revolutionize Secondary Recovery. C. O. Fairbank. *Oil Wkly*, 29.11.43, **111** (13), 11–14.—An account is given of early work by Ranney on horizontal wells for water. Horizontal wells have been drilled on the continent of Europe, in England, America, and, at present drilling, in Australia. The Ranney well installation at Franklin, Pennsylvania, has proved that horizontal holes can be drilled 2000 or 3000 ft, or even farther, and, knowing their elevation at any point, they can be turned up or down at will. The first pair of wells in the Franklin installation of the Venango Development Corporation are approximately level with the mouth at 1500 ft., and from there on slant slightly upward. At 2000 ft. each well is about 12 in. above the starting point. The 8-ft.-diameter Franklin shaft is 429 ft. deep, ending in a 27-ft. circular work-chamber in the oil-sand. From a level 1 ft. above the bottom of the sand stratum to be worked 24 wells are to be drilled, like spokes of a wheel, out to property lines. All wells will flow by gravity to an enclosed tank, and one big pump will lift the fluid to the surface. The results of shooting a long horizontal shaft are awaited with interest by the American oil industry. A. H. N.

339.* Field Reconditioning of Milling Cutters Speeds Side-Tracking Jobs. E. Sterrett. *Oil Wkly*, 29.11.43, **111** (13), 28.—The alloy-steel cutters are almost without exception heat-treated to normalize stresses after working; the field technique involving preheating before and during the reforming operations. The worn cutters, after inspection to determine the possibility of deep fractures which might result in a second fishing job, are heated in a specially designed gas-fired furnace, and the hard-facing metal applied while the body of the tool is at the proper temperature for best working. The furnace is in the form of a sheet-metal muffle, with a number of gas-burners in the base, and with a screw-jack at the outer or shank end to permit accurate adjustment of the level of the cutter between the supporting yokes. The furnace is described in detail.

Use of the combination preheating furnace and welding jig enables all welding to be done downhand, in the flat position. The adjustable copper alignment plate, fitting snugly against the milling cutter, also retains the heat in that portion of the tool next to be reconditioned, making for most desirable welding conditions. By fitting a hood over the furnace top, and by slowly rotating the cutter in its supporting yokes, some operators also secure a satisfactory normalizing action which completely relieves the cutting edges of localized stresses. The time required for field rebuilding with a competent welder is no longer than that required for a shop job, and the cutter, as soon as reconditioned, is again ready to resume milling in the hole. A. H. N.

340.* Reducing Rotary Drilling Hazards in Rocky Mountain Operations. N. Williams. *Oil Gas J.*, 9.12.43, **42** (31), 43–45.—Hard, abrasive, and steeply dipping formations have created many problems for rotary drilling in the Rocky Mountain area. In general, these problems have to do with excessive wear on bits, tool-joints, and drill-pipe; slow drilling, and the hazards of crooked hole, sticking of drill-pipe, and twist-offs. All are closely interrelated, and combine to contribute to the exceptionally high drilling costs which characterize operations in this area. Rock bits are necessary for all drilling in the area, and formations are so hard that few wells going to depths of 4000–5000 ft. can get along with fewer than 50–60 bits. In many wells the number is much greater than that. Bit footage is often measured in inches rather than feet. Typical of this was a section of 100 ft. in a recent well in which 100 bits were required, an average of 1 per ft. Another recent well drilled to 9200 ft. used more than 400 bits. The technique used to reduce hazards and expense is described.

Drilling of straight hole has been facilitated in most operations by the use of comparatively long drill-collars. Usually as much as 90 ft. is run on the string. This tends to concentrate the weight on the bottom and prevent flexing at that point. Most drilling contracts in the Rocky Mountain area provide for a maximum hole deviation of from 4° to 5°. However, as a result of practices followed and the control maintained, many of the holes are kept well within that range. Only backing up and use of whipstock can straighten a crooked hole in this area, as the formations are very hard. Tool-joint wear is severe. Of particular significance is the fact that in most instances the wear on tool-joints and pipe is only on one side, usually about a third of the diameter. So far no satisfactory explanation has been made of this peculiarity. Life of tool-joints and pipe-strings is being greatly prolonged by modern developments in rebuilding of tool-joints. A. H. N.

Production.

341.* Gravity Drainage in Oil Fields. J. O. Lewis. *Petrol Tech.*, September 1943, **6** (5), A.I.M.M.E. Tech. Pub. No. 1611, 1–22.—It has long been recognized that gravity is one of the three important natural forces for expelling oil from the reservoir rock. Each of the three forces acts physically to overcome the surface energies that hold the oil within the pores, and mechanically to overcome viscous resistance and to propel oil through the reservoir rock to the wells. The ability to perform the first function is most important, for this sets a limit to oil recovery. Gravity and water are relatively good displacing agents, whereas it takes a great expenditure of gas to remove a high percentage of the oil. Gravity is always present, but it is usually the feeblest of the three agents in terms of mechanical energy. Generally the three agents interfere, and only one can be used effectively at a given time and place. The dominant agent may differ in different parts of the reservoir, and it may change with time.

In gravity drainage there is an upper zone of low saturation with flow controlled by capillarity, and a lower zone which is fully saturated, with flow obeying hydraulic laws.

In the pendular zone and the thinner funicular zone developed in gravity drainage of a sand there remains in a uniform sand 5–25% of oil which is irrecoverable. The figure may be even higher in fine-pored sands. In sands of low dip and fine pores, and having low vertical permeability, the rates of drainage may be uneconomically low. In irregular sands the retention in the pendular region is often higher than in uniform sand. When the free surface is being lowered rapidly the funicular zone may become drawn out. The more depleted the pores the slower is the rate of drainage from them, and the rate of flow in the saturated zone is alone largely capable of control.

Under high pressure the increased amount of gas in solution will favour gravity drainage.

When gas comes out of solution there will be a critical rate of gas flow and gas–oil ratio for a given sand below which oil can flow downward under gravity and displace the gas, causing the gas to flow at higher levels. Above this velocity, dissolved gas-drive conditions will obtain. Segregation and gravity drainage may be going on in part of a reservoir while gas drive is going on in other parts not far distant. Transient gas caps may form.

When the gas is largely depleted and its rate of flow can no longer prevent oil draining downwards, an extensive funicular zone will gradually collapse with the downward drainage of oil, leaving a pendular upper region, and creating a saturated lower region. Such a transition has been recognized in the Oklahoma City and other pools.

Gravity drainage requires that a gas cap be formed and spread, but the mere spreading of a gas cap does not necessarily mean that gravity drainage is working effectively. Gravity drainage in the capillary zone sets a pace which must not be exceeded if dispersed gas-drive conditions are to be prevented. It would appear that the nearer pressures can be kept to solution pressures, the less will evolved gas interfere with the desirable functions of gravity, and the faster can oil be taken from below the gas–oil contact without causing dispersed gas-drive conditions.

Careful gas injection and production control may make it possible to change gas-drive to effective gravity drive in some pools.

Gravity drainage may be put into effect in one of four ways : 1. Maintain a pressure equal to or greater than the original solution pressure. 2. Restore or partly restore gas pressure after partial pressure depletion. 3. Reduce pressure sufficiently slowly to permit gas and oil segregation. 4. Produce the field first by gas-drive until most of the gas is removed, and then by gravity drainage. The last two methods cannot be applied when edgewater encroaches rapidly. On the whole it seems that the best results can be expected by maintaining pressures and controlling production rates.

Gas–oil ratios can be used to give some idea of whether gravity drainage is operating, and if so, whether it is operating effectively. Generally only the wells with the lowest gas–oil ratios should be used. It appears that gas-drive does not develop until about 10% of the pores are filled with gas from solution ; until that point the oil moves under fluid expansion and hydraulic flow.

When the gas–oil ratios increase suddenly from comparatively low values (the drainage being under high pressure), there is reason to believe that there is an expanding gas cap, and that the sand is under gravity drive and a gas–oil front has reached the well. In non-uniform sands there will be several gas–oil fronts, and it becomes more difficult to tell whether a front has reached the well or whether the increase denotes gas-drive.

Four examples of gravity drainage are described. In three of the fields the gas was blown off in a gas-drive stage, and then the oil drained down-dip under low pressure ; in the fourth field, gravity drainage took place under partly maintained pressures.

Field evidence shows that in some reservoirs gravity drainage has resulted in recoveries equal to or perhaps exceeding that which could be expected from water displacement. It is generally admitted that under field conditions, dissolved and dispersed gas drive almost always result in the lowest economic recovery, and should only be used where other agents are not effective, or where their use is justified by some economic advantages.

G. D. H.

342.* Selective Adsorption of Hydrocarbon and Water Vapour on Alumina at Atmospheric Pressure. C. C. Ku, R. L. Huntingdon, and L. S. Reid. *Petrol. Tech.*, November 1943, 6 (6), A.I.M.M.E. Tech. Pub. No. 1628, 1–13.—It becomes increasingly important to dehydrate natural gas when the operating pressures employed in gas processing and transmission are increased above 500 lb./in.^{2}. Without dehydration, gas temperatures must be held at relatively high levels to prevent solidification of natural-gas hydrates, thus creating conditions which are unfavourable for the processing of the gas for its gasoline content at high pressures.

The simultaneous adsorption of water and hydrocarbon vapour from natural gas by three grades of alumina has been studied at atmospheric pressure and temperature. The apparatus and methods are described, and the results of this investigation show that the presence of water vapour in the gas inhibits the adsorption of hydrocarbon vapour, although the presence of the latter does not have a pronounced effect on the adsorption of water vapour. Adsorption of water–hydrocarbon mixtures from gas shows three successive phases. In the first, both water and hydrocarbon vapour are adsorbed; in the second, adsorption of water vapour proceeds while desorption of hydrocarbon takes place; in the third phase, the adsorbent approaches complete saturation with respect to both water and hydrocarbon vapour.

The ratio of hydrocarbon to water adsorbed can be varied either by changing the length of the cycle or by varying the quantity of solid adsorbent.

An example is given of the application of the experimental data and the theory to the design and operation of commercial dehydration plants. G. D. H.

343. Vapour-Liquid Equilibria of Natural Gas–Crude Oil Systems. M. B. Standing and D. L. Katz. *Petrol. Tech.*, November 1943, 6 (6), A.I.M.M.E. Tech. Pub. No. 1651, 1–14.—Data on the composition and densities of co-existing vapour and liquid phases have been obtained for four different systems of natural gas and crude oil of constant composition, over a range of pressures from 1000 to 8220 lb./sq. in., and temperatures from 35° to 250° F. The compositions of the hydrocarbon systems were such that the critical temperatures of the mixtures were lower than the range of the investigation. The apparatus and the experimental technique are described, and the experimental data and computed results are presented in tabular and graphical form. The system of crude oil and natural gas having a gas–oil ratio of 3660 cu. ft./brl. has a critical temperature less than 35° F. In the retrograde region the density of the equilibrium liquid phase passes through a minimum value with increasing pressure. The over-all composition of the system has a marked effect upon the values of the equilibrium constants at pressures above 1000 lb./sq. in. For the constant composition systems studied, the equilibrium constants of the components other than methane and heptanes-and-heavier, when plotted against pressure, tend to converge to $K = 1$, at a decreasing rate. In the retrograde region the behaviour of the heptanes-and-heavier equilibrium constant with pressure differs from that of the pure components in the system, because of the decrease in volatility of the heptanes-and-heavier fraction in both the vapour and liquid phases with increase in pressure on the system.

G. D. H.

344.* Repressuring " Aired-Out " Sands. F. R. Cozzens. *Oil Wkly*, 1.11.43, **111** (9), 15–16.—Many areas exist which have been subjected to faulty air-drive production technique and have been abandoned. A very necessary initial step in bringing an " aired-out " sand back into production is to obtain a good working knowledge of its structure, and some reliable evidence as to how the former pressuring method was applied. Operators who have been most successful with the venture drill their input or induction wells first. These wells are carefully logged from the moment the pay-sand is tapped until the bit reached the bottom, by drilling two-foot screws. Sand samples are thus taken from the various zones and analysed. It is generally learned from these samples that the tighter and more restricted sand zones are rich in oil content. The most fertile zones are then measured with a steel line to ascertain the length of sand-face, and are later shot with as much nitro-glycerine as the bore will hold. In most cases, 4½-in. shells are used, which allows 3·4 quarts of nitro-glycerine to each foot of sand. The purpose of this type of shooting is thoroughly to fracture the tight stretches of sand, and to secure better effects the shell is generally held down and anchored with 6–10 brl. of water. After the blast, the well is immediately cleaned of residue, and made ready for the setting of packers. The soft sand zones are rarely shot, but are measured carefully as to length of sand-face, then cemented off. The measuring procedure is important because these soft zones play an effective part in the final stages of oil recovery. Packers are usually of the commercial rubber or expanding type, set in cement immediately above and below the fractured sand zones and air is inducted, in most cases through 1-in. tubing.

Producing wells, while of no lesser importance, are generally completed with less labour and time. Tight sand zones are measured off, shot with quantities of nitroglycerine sufficient to fracture them thoroughly, and cleaned of residue. Soft sand portions, unless water saturation is excessive, are left open. Well arrangements and methods for reviving and bringing in of these wells are given in brief. A. H. N.

345.* Surface-Tension Effects in Secondary Recovery. P. D. Torrey. *Oil Gas J.*, 11.11.43, **42** (27), 210. *Paper Presented before American Petroleum Institute.*—Work performed principally with a view to studying natural drives is reviewed in the belief that it is applicable to artificial drives. The adhesion-tension relationships under conditions where water and oil are brought in contact with the surface of a solid have been illustrated by Benner, Riches, and Bartell. Sso, Ssw, and Sow represent the interfacial tensions at the solid-oil, solid-water, and water-oil interfaces, respectively. (The subscripts s, o, and w, indicate solid, oil, and water phases, respectively.) If Sso is greater than $Sow + Ssw$, the water will spread over the surface of the solid, displacing the oil therefrom. If Sso should be less than $Sow + Ssw$, the system will come to equilibrium at some definite contact angle $\theta\, ow$, as measured through the water phase. Thus at equilibrium :

$$Sso - Ssw = Sow \cos \theta$$

and

$$Sso - Ssw = Asw - Aso = Sow \cos \theta,$$

where A is the adhesion tension.

The magnitude of Asw and Aso, the adhesion tensions of water and oil, respectively, against a solid, determine whether a given solid will be wet to a greater extent by water or oil. If Asw is greater than Aso for a given solid, that solid is preferentially wet by water. As determined by Bartell and Miller, no oil investigated had an adhesion tension greater than that of water, although there is considerable variation in the degree of wetting of silica in crudes from different sources. Therefore, it would follow, in artificial water-flooding, that the more the adhesion tension (Asw) between the solid and water exceeds the adhesion tension (Aso) between the solid and oil, the more effective will be the displacement of the oil by the introduced water. In like manner, if the value of Aso approaches that of Asw, the amount of spontaneous displacement will be small, as indicated by the height that water might rise in an oil-coated capillary. If Aso should equal Asw, or if Aso should be greater than Asw, no spontaneous displacement will take place. Therefore, it can be deduced that an oil having a low adhesion tension to the reservoir rock should react more favourably to water-flooding than one having an adhesion tension approaching that of the injected water. Furthermore, the pressures required to force water into a sand containing a crude possessing a low adhesion tension should be less than for crudes having higher adhesion tensions. Only work on pure silica and calcite is reported ; further work on solids containing clay particles is needed.

From the foregoing it is evident that measurements of the angle of contact formed between the solid-rock material and the parts of reservoir liquids should be an indication of the degree of wetting of the reservoir. If the angle of contact between the solid, water, and oil ($^{\theta}\, swo$), as measured through the aqueous phase, is less than 90°, it is believed that the water preferentially wets the rock, and will displace the oil therefrom. However, if the angle is greater than 90°, the rock would be wet preferentially by oil, and the oil would displace water. If the angle should be exactly 90°, the system would be in equilibrium, with no displacement action. A. H. N.

346.* A New Application of Water Injection for Maintaining Reservoir Pressure and Increasing Natural Drive. W. L. Horner and D. R. Snow. *Oil Gas J.*, 11.11.43, **42** (27), 266. *Paper Presented before American Petroleum Institute.*—See Abstract No. 351. A. H. N.

347.* Standardization of Electrical-Log Headings. W. L. Jarvis. *Oil Gas J.*, 11.11.43, **42** (27), 238. *Paper Presented before American Petroleum Institute.*—This recommended electrical log heading has been designed to include as much of the pertinent available data as is feasible to record. It represents, as nearly as can be reached, a broad consensus of the Californian industry as to what a desirable heading should contain. A. H. N.

348.* Influence of Fluid Saturation on Secondary Recovery of Oil. P. A. Dickey. *Oil Gas J.*, 11.11.43, **42** (27), 274. *Paper Presented before American Petroleum Institute.*—Perhaps the most important single fact that determines the success of secondary-recovery operation is the amount of oil recoverable. This amount is determined by the amount of oil in the sand. Possibly the next most important fact is the injected gas–oil or injected water–oil ratio necessary to recover this amount of oil. These ratios are determined by the gas and water saturations of the sand. It is clear that if these quantities were determinable by cores in advance of the heavy development expense incident to either gas or water drives, much of the hazard would be removed from secondary-recovery operations. The importance of further work on the fluid relationships in oil-sands as they affect productivity indices, and on methods of obtaining representative cores, cannot be over-emphasized.

The greater the remaining oil saturation of a sand, the larger the fraction of that oil that can be recovered by secondary-recovery methods. The cost of producing oil increases as the production/well decreases. For these reasons it is economically important to start pressure-control operations as early as possible in the life of a pool. In the case of old pools the longer secondary-recovery operations are postponed, the higher will be the cost/barrel of recovering the oil. A. H. N.

349.* Permeability as Related to Productivity Index. N. Johnston and J. E. Sherborne. *Oil Gas J.*, 11.11.43, **42** (27), 290. *Paper Presented before American Petroleum Institute.*—The fundamentals of calculating flow from a reservoir by the ordinary formula are discussed, taking each factor separately and studying its effects on the flow. The importance of reservoir viscosity of oil is shown to be equal to that of sand permeability itself in determining flow. A modified specific productivity-index function is developed which bears a simple theoretical relationship to sand permeability. Pertinent data are tabulated on 141 California oil-wells on which, through core analysis and productivity index, data were available. The modified specific productivity-index function is studied graphically for these wells. The conclusion is reached that, although the well behaviour for high-permeability sands approximates the theoretical, there is an increasing deviation between actual performance and theoretical with decreasing permeability. A. H. N.

350.* Factors Governing Selection of Prime Movers for Oil-Well Pumping. J. Zaba. *Oil Gas J.*, 18.11.43, **42** (28), 50.—From the standpoint of the prime mover itself, the cost of investment and maintenance, the efficiency of converting the energy into developed power, the availability of field personnel familiar with given types of prime movers, availability of repair facilities, all have to be weighed against each other. Analysis of costs and loads includes many factors. If gas engines are under consideration, a study must be made of type of gas available, whether it is sweet or sour. Possible future cost of gas must be considered. Available gas reserves are important. In a new field, gas is usually abundant. During the later stages of the producing life of the field, however, gas may not be available, and later conversion to the electric power, representing second capital investment in cost of production, may prove uneconomical. Cost of gas-gathering and distributing system must be included in calculations of the investment, and cost of maintenance of the system in the operating expense. In many cases the type of available water may have a bearing on the problem. If a circulating cooling system is to be used, the possibility of cost of treatment of water must not be disregarded. Similar considerations must be applied to decision on selection of oil-engines. That means the type of oil available, cost of transportation, and market value of oil, and question of water supply. In case of electric power the initial cost of distribution system, the terms of contract and cost of power, maintenance cost of the system, types of loads encountered, all have to be analysed. Once electric power has been decided upon, further selection must be made between use of utility power and of private generating plant. To arrive at such decision the original cost of private generating plant and its operating cost, particularly that of fuel, have to be compared with cost of bringing the utility power to the lease and actual cost of utility power. Questions of future increase in power demand, because of increase in water content of the produced fluid, probable life of the field, spacing of wells are also important factors.

After summarizing the factors involved, the paper discusses internal-combustion engines, both liquid and gaseous fuel types, and electric motors characteristics in general terms. A. H. N.

351.* A New Application of Water Injection for Maintaining Reservoir Pressure and Increasing Natural Water Drive. W. L. Horner and D. R. Snow. *Oil Wkly*, 22.11.43, **111** (12), 17. *Paper Presented before American Petroleum Institute.*—The most important objectives sought for any field are: (1) maximum ultimate yield; (2) maximum production rate/well at minimum cost/barrel. To attain these objectives, control of reservoir pressure is a factor of greatest importance. For this purpose a method for maintaining original reservoir pressure by increasing the natural water drive was devised and is being practised in the Midway Field, Arkansas. So far as known, this is the first instance in which injection of extraneous water has been applied to an entire pool—and in the very early stages of its productive life. This method should be applicable to many other newly discovered or partly depleted oil-pools where a deficiency of natural water drive can be recognized or where reservoir conditions are such that artificial water drive could be applied. Data from Midway Field, Arkansas, are presented which demonstrate a certain degree of control over pressure behaviour in a large part of the reservoir by means of fresh-water injection. Reservoir pressures were increased in an area 1 mile in diameter during a period when withdrawals from the pool as a whole were considerably increased. Over the five-month period following initial injection, the average reservoir pressure for the entire field declined at a negligible rate, whereas until that time the average reservoir pressure had fallen at the rate of approximately ½ lb./sq. in./day.

It is concluded that the results obtained at Midway will invite the adoption of this practice in other pools. Careful study and caution are appropriate when different conditions are met. Under certain conditions other secondary means of control would be found preferable. In many similar reservoirs, however, there is every likelihood of its successful and profitable application. A. H. N.

352.* The Criteria for Determining an Oil-Field's Susceptibility to Secondary Recovery Methods. Anon. *Oil Wkly*, 22.11.43, **111** (12), 23. *Submitted by the Standing Sub-Committee on Secondary-Recovery Methods of the Topical Committee on Production Practice, Division of Production, American Petroleum Institute.*—The fact that secondary-recovery operations may yield very satisfactory results in one certain field is no definite criterion that the same degree of success will be attained in others, even though they may be located in close proximity and produce from the same oil-bearing formation. Unfortunately, in the past elaborate plants, involving very considerable investments, have been installed without proper investigation of reservoir conditions, just because secondary-recovery operations in nearby areas have been successful. By accident, some of the projects so commenced have produced a satisfactory recovery, but in other instances the increase in production has not been sufficient to return the development expenses. Part I of this paper gives in scheduled sequence the information required for a study of secondary-recovery possibilities of an oil-field. This schedule is most detailed. A. H. N.

353.* Determining Probability of Success of Secondary Recovery Operations. Part I. J. H. Cable. *Oil Wkly*, 29.11.43, **111** (13), 17. See also *Oil Gas J.*, 11.11.43, **42** (27), 199. *Paper Presented before American Petroleum Institute.*—The paper deals with the two problems, gas-injection and water-flooding. For gas injection: a proposed gas-injection project must necessarily include facilities for the injection of gas or air into the producing horizon. Designing suitable equipment requires a general knowledge of the installed producing facilities and an accurate evaluation of the volumes and pressures necessary for a successful and profitable venture. Preliminary field tests and the assembling of comprehensive data are necessary. The field tests necessary for the design of a gas-injection project include the determination of reservoir characteristics as they pertain to the amount of displacement necessary for profitable results, the required volumes of injected gas to obtain this displacement, and the availability of the necessary injection medium.

For water-flooding a preliminary examination of the project may or may not justify the expenditures necessary for a detailed analysis of the probable increase in recovery and the equipment required to complete the installation. If the survey is justified, it is important that one or more strategically located wells be cored through the producing horizon. After theoretical calculations have been made, possibly after a pilot-plant operation has been studied, the project's maximum volumes and pressures have been determined, and analyses of the available water supplies have indicated the proper treating method, then the design of the plant is simple. The advisability and design of a water-flooding project should be based on a proper analysis of the information acquired in the field and laboratory. A. H. N.

354.* Determining Probability of Success of Secondary-Recovery Operations. Part 2. C. R. Fettke, P. A. Dickey, D. Rogers, R. P. Torrey, and C. J. Wilhelm. *Oil Wkly*, 6.12.43, **112** (1), 24. *Paper Presented before American Petroleum Institute.*—In order to analyse the influence that geologic factors have on the secondary-recovery possibilities of a particular pool, the available subsurface geological information and production data should be assembled in graphic form on a structure map on top of the oil-sand and on an isopach map of the sand. A number of sections parallel to the long axis of the pool, and at right angles to it, should be constructed. In connection with the study of data, the effects of primary reservoir performance on secondary-recovery possibilities should be taken into consideration. If the preliminary investigation indicates that the pool or tract has secondary-recovery possibilities, a core-testing programme should be laid out to check and supplement the geological data on the sand body and to obtain information in regard to the porosity, oil and water saturation, and permeability of the sand.

The amount of oil recoverable by secondary-recovery methods is a deciding factor in determining the feasibility of such an operation. The procedure for its determination is outlined. Sand uniformity in relation to secondary recovery is analysed. Texture and mineralogical composition of the sand are considered. The influences that shale partings in the sand, the shape and geological patter of reservoir, structure, and depth of the sand have on secondary-recovery operations are discussed. The geological factors that have to be taken into consideration in selecting the method of secondary recovery best suited to meet certain conditions are pointed out. Limestone reservoirs are briefly discussed. Many pools possess geological features that permit most efficient exploitation by secondary-recovery methods only when some form of unitization is adopted. A. H. N.

355.* Factors in Selection of Surface Pumping Equipment. J. Zaba. *Oil Gas J.*, 9.12.43, **42** (31), 50.—The selection of a pumping unit resolves itself into a consideration of several interrelated factors. In addition to the necessity for determining expected peak loads and calculation of peak torque, questions of counterbalance, length of stroke, minimum downstroke loads, and speed of operation have also to be considered. These are briefly studied. The A.P.I. standards of rating are given with a short discussion. The formulæ given in the specifications assume existence of certain specified conditions, such as proper counterbalancing, absence of torsional vibration, good repair of surface pumping equipment, proper foundations and others. Under these assumptions standards are given for design of gears, housing, shafts, and bearings, and formulæ for calculations of peak torque ratings of gears and roller chain drives.

The standards also include suggested method for computing of well loads for the purpose of calculating the peak torque when other data are not available. Slonneger's formula is recommended for this purpose. Cognizance is given to the fact that the formula does not give close agreement under all conditions, with actually measured loads. Work is being done on correlation of available data in order to determine if any other of the available well-load formulæ should be substituted, but for the time being, as in the past, Slonneger's formula is still recommended. Denoting by P the peak polished-rod load as calculated from the load formula, the A.P.I. specifications recommend the following method for arriving at the resulting peak torque to be used for rating of reducer :

$$NL = 0{\cdot}4P \text{ or } NL = P - CB \text{ — whichever is larger}$$

where NL = net peak polished-rod load, lb., CB = actual effective counterbalance force, lb.

After the net peak polished-rod load is determined, the peak torque is arrived at from the formula :

$$T = NL \times \frac{S}{2},$$

where T = peak torque, inch-pounds, S = polished-rod stroke, inches.

A. H. N.

356. Drilling and Production Patents. T. B. Wayne. U.S.P. 2,331,279, 12.10.43. Appl. 31.3.39. Treatment of mud-laden drilling fluids.

T. B. Wayne. U.S.P. 2,331,280, 12.10.43. Appl. 31.3.39. Treatment of mud-laden drilling fluids.

T. B. Wayne. U.S.P. 2,331,281, 12.10.43. Appl. 31.3.39. Treatment of mud-laden drilling fluids.

T. B. Wayne. U.S.P. 2,331,282, 12.10.43. Appl. 5.6.39. Treatment of drilling fluids.

H. W. Ballad. U.S.P. 2,331,293, 12.10.43. Appl. 5.11.41. Whipstock.

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A. H. N.

Transport and Storage.

357.* Calculating Fractional Contents of Horizontal Cylindrical Tank. R. G. Lovell. *Petrol. Engr*, Nov. 1943, **15** (2), 87–92.—A method is described for preparing tables to show the contents of cylindrical tanks placed in a horizontal position, from a determination of the dip. Such tables are intended for use where the cost of accurate strapping is not justified, but where a reasonable degree of accuracy is still required, such as in refinery operating tanks. As illustration, tables are developed for a cylindrical tank 8 f t.1½ in. in diameter by 18 ft. 10½ in. long, and having bumped ends of radius equal to that of the cylindrical section. R. A. E.

358.* Internal Insulation for Pipes Under High Pressure. W. H. Hill. *Petrol. Engr*, Nov. 1943, **15** (2), 165–166.—The limited availability of high-alloy steels for use in processes involving high temperatures and pressures has resulted in the development of internal insulation of pressure pipes which permits the use of carbon steel for their construction. Insidline construction, developed by the Baldwin-Hill Co., consists of a layer of insulating material placed against the inner surface of the pressure piping and retained and protected by metal liners suitably arranged. The insulating material is a felted block with a diatomaceous earth base reinforced with amosite asbestos fibres. The inner liner is not required to resist pressure, and is therefore not made pressure tight. The composition and thickness of the liner can be varied to suit conditions of temperature, corrosion, erosion, and velocity.

The primary objective of the system is to hold the temperature of the pressure piping to 650° F. or lower to permit the use of carbon steel pressure piping. The secondary objective is heat conservation.

Methods of construction used for varying sizes of pipe, for elbows, and for expansion joints are described. Temperature distribution in pipes having internal insulation under varying conditions of air temperature and wind velocity are illustrated. Applications for a variety of purposes have been made for pressures up to 300 p.s.i., temperatures up to 1500° F. and velocities up to 500 ft. per sec. R. A. E.

359.* Water Film Most Apparent Cause of Corrosion in Susquehana Pipe-Line. J. M. Pearson. *Oil Gas J.*, 11.11.43, **42** (27), 254–258.—The Susquehana pipe-line was one of the first designed for products distribution, and in the first section constructed no provision for line clearing was made, since internal corrosion was not anticipated. Friction measurements, corrected to standard conditions, were taken over a number of years, and the results presented show the increase in friction with time and the improvement achieved when arrangements for scraping at regular intervals were installed. There is no evidence yet that serious internal pitting or reduction of wall thickness has occurred or that internal corrosion exceeds 0·1% of pipe wall per annum. The use of small test specimens in the line has been discontinued, as results bore no relation to service experience. The cause of interior corrosion appears to be the water film which adheres to the inner pipe wall. In the presence of light products the wall is preferentially wetted by water, but when heavier products are pumped, some waxy constituents appear better able to wet the walls than water, and hence tend to cover and protect it. The presence of the water film and availability of oxygen in the gasoline stream enable corrosion to proceed, and in an untreated unscraped line the form taken is similar to that of corrosion in moist air. The amount of water adhering to the walls in a 6-in. line is estimated at 1½–2 brl. per mile. The amount of oxygen required to oxidize the iron removed as scale is about one-tenth of that required to saturate the gasoline stream at atmospheric pressure.

Since internal corrosion is small and distribution even, the main problem to solve was maintenance of line capacity, for which scraping was found effective. The type of scraper used is described.

With regular scraping, pairs spaced 15–30 mins. are run, but where conditions preclude regularity it is usually better to run more than 2, or to run pairs at more frequent intervals to restore line capacity. In general, the corrosion and the scrapers used to maintain capacity have had no bad effect on the products pumped, the segregated material, after removal of debris, being suitable for delivery. R. A. E.

360.* Sodium Nitrite as Corrosion Inhibitor in Gasoline Lines. S. S. Smith and R. K. Schulze. *Oil Gas J.*, 25.11.43, **42** (29), 62.—In a paper presented before the A.P.I. meeting, Chicago, Illinois, in November 1943 as contribution to the "Symposium on Combating Internal Corrosion of Products Pipe-lines" a review is given of developments in the use of sodium nitrite solution for inhibiting corrosion in pipe-lines carrying gasoline. The solution is injected at each pump station, caustic soda being added to give the effluent water a p_H value of 7 or higher. The Wood River–East Chicago line has been treated since September 1939, the rate being increased to 4 lb./day in September 1940, and in September 1942 the running of scrapers was found to be unnecessary. Several other lines have been similarly treated, it being found necessary to maintain over-inhibition and the use of scrapers when converting crude lines into products service, in order to remove the protective coatings formed during crude service. When scale removal is reduced to a low level, the amount of inhibitor used can be reduced, it being advisable to maintain 1–2% inhibitor concentration in the effluent water and to keep the amount of water in the line as low as possible.

C. L. G.

Crude Petroleum.

361.* An Investigation of U.S.S.R. Crude Oils. (Translated from *Zhurnal Prikladnoi Khimii*, 1939, **12** (4), 563.) G. D. Gal'pern and G. A. Musaev. *Petrol Engr*, October 1943, **15** (1), 98–104.—The investigation was undertaken with the object of accumulating experimental data which will aid the creation of a genetic classification of crude oils. It will throw some light on the relation between the components of crudes (hydrocarbon and non-hydrocarbon), their history, sources, and conversions during geologic time. Samples of 10 different crudes, 4 Pliocenic, 2 Miocenic, 2 Oligocenic, and 2 Carbonaceous have been partly examined, and work is still proceeding.

Tables presented show (1) location of wells and age of oil-bearing sands, (2) yields of cuts obtained at various temperatures during distillation of up to 250° C. in a Widmar-Dobryanski tower, (3) refractive indices of fractions and gravities of crude oils, (4) results of determination of the free and combined bases, strong acids, phenols and weak acids, carbenes, asphaltenes, and silica gel resins.

Methods employed for the isolation and determination of the contents of these materials are described and departures from normal analytical procedure clearly indicated.

The preliminary results indicate some relation between the content of bases, strong acids, and properties of the light fractions, particularly for crude oils of about the same geological age. A high phenol content was noted in the case of Old Grozny and Neftedag crudes and merits further investigation. R. A. E.

Gas.

362.* Normal Butane. R. C. Alden. *Oil Gas J.*, 29.4.43, **41** (51), 59. See *Refiner*, May 1943, **22** (5), 145 (*J. Inst. Petrol.*, 1943, **29** (239), 412 A, Abstract No. 1072).

C. G. G.

363.* Reforming Refinery Still Gases for Market Consumption. R. L. Bevan. *Oil Gas J.*, 19.8.43, **42** (14), 52.—Since October 1943 the Union Gas Co. of Canada has operated a reforming unit in which surplus cracking still gas from the Sarnia Refinery of the Imperial Oil Co. is processed to make it interchangeable with the Union Co.'s natural gas, which is widely distributed throughout this district for use as fuel.

From 2·6 to 6 million cu. ft. of refinery gas is passed daily to the adjacent premises of the Union Co., its calorific value being determined. This varies from 1200 to 1800 B.T.U. per cu. ft. Before reforming, H_2S is removed by the Burrell–Dayton lime slurry process.

The gas is then passed to the reforming equipment, where a proportion (approximately one-quarter) is reformed by the Faber process to yield a 400 B.T.U. gas. The reformed portion is cooled and washed by a water spray, and passed to an oil scrubber for naphthalene removal. Tar and condensable impurities are separated in Cottrell electrical precipitators. The clean reformed gas is then reblended with the untreated still gas to produce a mixture of 1000 B.T.U., which passes to storage. Before distribution the gas is compressed and passed through high-pressure oil-scrubbers to remove the last traces of naphthalene.

The total overall thermal conversion efficiency is 96·15%.

The following equipment is briefly described: (*a*) lime-slurry sulphur removal equipment; (*b*) reforming generators (six units each of 1 million cu. ft. per day capacity); (*c*) oil-scrubbers; (*d*) Cottrell precipitators; (*e*) gas-holders; (*f*) steam boilers for heating; (*g*) water-pumps; (*h*) gas-engine compressors. C. G. G.

Cracking.

364.* Octane Number of Catalytic Gasoline Varied by Operating Methods. E. V. Murphree, C. L. Brown, H. G. M. Fisher, E. J. Gohr, and W. J. Sweeney. *Oil Gas J.*, 3.6.43, **42** (4), 51. See *Industr. Engng Chem.*, 1943, **35**, 768 (*J. Inst. Petrol.*, 1943, **29** (238), 386 A, Abstract 990). C. G. G.

365.* Sunray Makes Codimer and Polymer Gasoline in Tandem Units. Anon. *Oil Gas J.*, 4.11.43, **42** (26), 32.—In order to obtain and retain the maximum amount of the non-selective high-octane-value polymer, and to raise the gasoline yield and reduce T.E.L. costs, a system was designed in which, by a selective polymerization of the total gases from a Dubbs unit, a codimer could be produced; and a polymer gasoline from a non-selective reforming unit, using the overhead gases from the codimer unit. The pressure distillate from the Dubbs plant is passed to a stabilizer operating at 345° C., the overhead temperature being 130° C., and is reduced to 6 p.s.i. Reid pressure, with a I.B.P. of 106° C., and E.P. of 400° C. The overhead gases, containing about 27% olefins and 0·04% sulphur, are desulphurized in a Girbotol unit. The H_2S-free gases are compressed to 500 p.s.i. in one stage and the temperature reduced from 220° to 120° F. and the water from the vapours separated. The vapours are heated to 335° F. and pass to the first of two catalyst chambers at a rate of 750,000 c/f/hour with 1,250,000 c/f/hour of dry gas as make-up to maintain the required gas volume. As the polymerization reaction is exothermic, some of the product stream is injected into the lower parts of the catalyst towers at 90–100° F. to offset the rise due to the reaction. The temperature is maintained steady at 335° F. to assist the polymerization of the butenes and limit the reaction of other olefins present. The yield of codimer in the effluent gases is 1·22%. The stream from the catalyst chamber passes to the codimer stabilizer, where it is stripped at 310° F. at 260 p.s.i., the top temperature being 130° F. The codimer flows from the bottom to storage, it has an A.P.I. gravity of 65, and a boiling range of 120–370° F. after a final stripping to a 5 p.s.i. Reid pressure and an octane value of about 82; and does not need any treatment. The overhead light gases from the stabilizer is divided, part for recycling, to the codimer unit, the balance being compressed to 550 p.s.i. and heated to 460° F. passing to another pair of catalyst towers for polymerization. In this unit no attempt is made to hold down the temperature, which rises to 490° F. at the catalyst tower exit. About 0·5% of water is added to prevent the catalyst drying and seriously reducing its activity. After passing out of the tower the vapours enter the polymer stabilizer, from which the overhead gases may flow for recycling, or for use as fuel. The polymer gasoline is taken from the bottom of the stabilizer. It has an A.P.I. gravity of 85, with an I.B.P. of 60° F., and E.P. of 374° F., with 50% temperature of 338° F., indicating a scarcity of light products, 45%, or more, distils between 338° and 374° F. The octane value is 72, the yield being 1·36%.

The combined system is capable of a wide range of operation. A simple flow sheet is shown. Tables I and II referred to in the text as showing the composition of the P.D. vapours and the distillation characteristics of the codimer, are missing.

W. H. C.

366.* Cracking Technology. Part 8. Calculations for Reforming Operations. C. R. Wagner. *Oil Gas J.*, 4.11.43, **42** (26), 40.—In determining the best returns that are possible in the reforming of straight-run gasolines, a useful guide is provided by the "octane-barrel-improvement" figure, which is calculated from the results of reforming tests on selected naphtha fractions. It is computed in the following way :—

Multiply the barrels of reformed gasoline made per 100 brl. of total straight-run gasoline in the crude, by the octane number of the reformed gasoline, and subtract the product of the brl. of reformer charge per 100 brl. of total straight-run, by the octane number of the reformer charge. The results of reforming tests on three naphtha fractions from an Illinois straight-run gasoline are given, when computed as described the "octane-barrel-improvements" are :—

250–400° : 55·7 (0·8 × 65·3 – 33·7) = 1032·7
300–400° : 36·5 (0·8 × 62 – 28·2) = 781·1
325–420° : 21·3 (0·8 × 56·7 – 20·5) = 529·5.

The lead susceptibility of the total gasoline produced, and the cost, per barrel, of reforming the naphtha are not considered in the computation. The T.E.L. requirements for the three blends of reformed naphtha, straight-run, and cracked gasoline, for 80, 81, and 82 octane ratings, in relation to per cent. yield of total gasoline, are shown in graphs. Graphs are given showing : (1) the rates of decomposition of *n*-paraffins in relation to boiling points, and (2) per cent. yields of debutanized naphtha (when yield of product is 80%) in relation to coil temperature. From the results it is possible to ascertain : (1) the best reforming temperature for a naphtha fraction, (2) the loss incurred in the reforming process, and the most suitable naphtha fraction selected to obtain the maximum yield by reforming, so that the finished blend may conform to a given specification. It is observed that the best returns are obtained by the reforming of a naphtha cut having as wide a temperature range as possible, as demonstrated by the "octane-barrel-improvement" number. W. H. C.

367.* Cracking with Catalysts. C. L. Thomas, N. K. Anderson, H. A. Becker, and J. McAfee. *Oil Gas J.*, 11.11.43, **42** (27), 131–142.—Certain fundamental principles to be observed in the manufacture of synthetic catalysts, particularly the silica–alumina type used in fluid catalytic units, are given. The superiority of synthetic over natural catalysts in regard to stability at high temperature is illustrated, and methods adopted to control quality of the commercially produced synthetic catalyst are described. For a given gas–oil consumption, natural catalysts produce more gasoline and less gas than synthetic silica–alumina, but the gasoline is more olefinic and less aromatic under comparable conditions. Although more expensive, the synthetic catalyst is thus much the superior for production of aviation base stock.

When oil vapours are contacted with catalysts, the extent of conversion into other products is dependent on operating conditions. An increase in conversion can be obtained by (1) a higher temperature, (2) a higher pressure, (3) a lower space velocity, and (4) a higher catalyst/oil ratio. In fluid catalytic cracking, space velocity is defined as the weight of oil charged per hour per weight of catalyst in the reaction zone, and catalyst/oil ratio as the ratio of weight of catalyst entering the reactor per hour to the weight of oil charged per hour.

The most important factors controlling product distribution are the type of catalyst, conversion level, and quality of charging stock. The subsequent discussion is limited to the use of U.O.P. type "A" catalyst. Using the conversion to mean the degree to which cracking reactions have taken place, increased conversion results in (1) increases, at accelerating rate, in dry gas and coke formation, (2) increase in a more linear manner in C_4 and C_5 fractions, with increase in saturation, resulting in a maximum for butylene yield at a given temperature, (3) increase in yield of gasoline up to a maximum followed by a decrease. If conversion is held constant, increase in temperature results in increase in yield of dry gas and decreases in yields of C_5, gasoline, and coke. Typical results obtained by once-through operations under varying conditions with properties and yields of products are tabulated. Increase in conversion in a given temperature range tends to reduce olefin content of all products, and in the gasoline range is accompanied by increase in aromatics, leading to superior leaded anti-knock ratings.

Increase in U.O.P. characterization factor of charging stock at given conversion and temperature results in increased unsaturation of all products and decreases in *iso*-paraffin content of C_4 and C_5 fractions and aromatics in aviatiôn gasoline.

The foregoing discussion has been limited to typical gas-oils boiling 400–750° F.; stocks of appreciably lower average boiling point require more severe processing conditions for a given conversion level and the products are less olefinic, gaseous products contain more *iso*paraffins and liquid products more aromatic. Conversely, heavier stocks crack more easily and the products are more unsaturated. Throughputs, yields, and product qualities for once-through and recycle operations on the same stock are compared.

Normally, aviation base stocks produced by fluid catalyst plants require treatment to reduce olefin content. This may be accomplished by (*a*) further catalytic treatment resulting in improved product quality but reducing potential capacity of the plant for cracking gas-oil, (*b*) acid treatment, which gives a less marked improvement in quality and involves loss of hydrocarbons and appreciable acid consumption, (*c*) liquid phase treatment in presence of U.O.P. solid catalyst which gives an improvement in quality comparable with acid treating, but enables the high-boiling material produced to be recracked. Catalyst regeneration and the operations involved in single-stage and two-stage plants are described. R. A. E.

368.* Recent Developments in T.C.C. Processing. T. P. Simpson, L. P. Evans, C. V. Hornberg, and J. W. Payne. *Oil Gas J.*, 11.11.43, 42 (27), 262–268.—The most significant development is the production of more rugged catalysts, particularly the bead catalyst, which has enabled improvements in equipment and processing technique to be applied. The main modifications are: (1) elimination of internal baffling in reactors, originally installed to ensure efficient contact between vapours and catalyst. This permits increased capacity and wider flexibility with respect to space velocity. An added feature is that reactors can be adapted to countercurrent or concurrent flow. (2) Improvements in the kiln used for reactivating catalyst and simplification of operation. Control of regeneration temperature is achieved without re-circulation of flue gas or catalyst, and surplus heat is used to produce high-pressure steam. (3) With bead catalyst, larger throughput or substantial increase in product quality can be achieved in a given plant conventionally operated, and with selected stocks it is possible to produce aviation base stock by one-step processing. (4) The range of suitable charging stocks has been extended from gas-oils only to include others, notably light and heavy virgin naphthas. These naphthas can be catalytically reformed to yield aviation base stocks having leaded octane ratings (AFD–1C) of 98–100 using bead catalyst. Products obtained from thermal reforming, polyforming, and hydroforming of virgin naphthas may also be employed.

The application of the process to the manufacture of motor gasoline is also discussed. R. A. E.

369. Patents on Cracking. W. L. Benedict. U.S.P. 2,319,199, 18.5.43. Appl. 16.5.41. In a conversion process a hydrocarbon oil in admixture with a metal halide catalyst is cracked in a vertical reaction zone. On removal from the lower portion of the reaction zone, a relatively clean oil and a liquid containing suspended catalyst are separated from the mixture. Charging oil is added to the relatively clean oil, and the mixed oils are heated to cracking temperature and introduced into the reaction zone at an intermediate point. Fresh metal halide catalyst is added to the liquid containing suspended catalyst, and the resultant mixture is introduced into the upper portion of the reaction zone. Vapours are removed from the upper portion of the reaction zone and subjected to fractionation and condensation.

C. H. Angell. U.S.P. 2,319,301, 18.5.43. Appl. 9.5.40. In a conversion process hydrocarbon oil is cracked in admixture with a powdered cracking catalyst. The resultant products are separated into vapours and a residual liquid containing the powdered catalyst. The vapours are fractionated to condense the heavier fractions. The resultant reflux condensate is thermally cracked, and the products thus formed are contacted with the catalyst-containing residual liquid in a vaporizing zone which is maintained under catalytic conversion conditions.

A. Woerner. U.S.P. 2,319,836, 25.5.43. Appl. 1.11.39. In a process for catalytically cracking hydrocarbon oils in the vapour phase, oils within the boiling range 250–380° C. are contacted at about 455° C. with a pulverulent cracking catalyst preheated to about the same temperature. Contact is maintained only for a limited time, which precludes substantial cracking in this zone. Catalyst and oil vapours are then passed to a second zone in which there is a greater volume of catalyst than hydrocarbon vapours. In this way deposition of coke on the catalyst is minimized, also diminution of activity of catalyst.

W. T. Hancock. U.S.P. 2,319,926, 25.5.43. Appl. 27.11.39. Petroleum oil substantially within the kerosene distillate–gas oil range is refined in the following way. A stream of the oil is passed through a cracking zone and there heated to cracking temperature. Cracked hydrocarbons are passed into a reaction zone containing a body of divided adsorptive material, and are subjected to cracking and polymerization. A body of the hydrocarbons in liquid phase is maintained within the lower part of the divided adsorptive material. Mixed liquid and vapour fractions are subjected to intimate contact and agitation within an extended height of the material above the liquid hydrocarbons. This is achieved by introducing the hydrocarbons from the cracking zone directly into the body of liquid hydrocarbons, so that the liquid fractions are upwardly displaced by the vapours. The material is thus constantly washed in the presence of vapours undergoing conversion. Polymers being formed are constantly removed. Finally, vapours are removed from the reaction zone and condensed to produce gasoline. Unvaporized residual oil and its contained polymers are withdrawn from the body of liquid hydrocarbons. H. B. M.

Hydrogenation.

370. Patents on Hydrogenation. A. V. Grosse and W. J. Mattox. U.S.P. 2,319,452, 18.5.43. Appl. 24.2.39. In the dehydrogenation of naphthene hydrocarbons, vapours of these hydrocarbons are contacted under dehydrogenating conditions with γ alumina supporting a compound of a metal selected from those in the left-hand column of Group V of the Periodic table, consisting of vanadium, columbium, and tantalum.

H. B. M.

Polymerization and Alkylation.

371. Patent on Polymerization and Alkylation. V. N. Ipatieff and H. Pines. U.S.P. 2,318,781, 11.5.43. Appl. 8.6.40. In a process for synthesizing hydrocarbons, an *iso*paraffin is alkylated with an olefin in the presence of a solid composite resulting from the heating of a mixture of aluminium chloride and a refractory porous material under superatmospheric pressure and at a temperature above the normal sublimation point of aluminium chloride.

D. G. Blaker. U.S.P. 2,320,118, 25.5.43. Appl. 22.4.40. In a process for the conversion of hydrocarbons a granular aluminium oxide catalyst is used. The catalyst consists of alumina which has been subjected to the action of an aqueous solution containing as the sole active component not more than 6% by weight of an alkalizing material, which on heating to a high temperature yields a non-volatile residue containing an element selected from the alkali metals and the alkaline-earth metals.

B. Sellmeyer. U.S.P. 2,320,199, 25.5.43. Appl. 30.11.40. In a process for alkylating low-molecular-weight paraffinic hydrocarbons with low-molecular-weight olefinic hydrocarbons to form paraffinic hydrocarbons, sulphuric acid alkylation catalyst, together with the hydrocarbons to be converted, are introduced into a reaction zone. The zone is maintained at conditions designed to vaporize unreacted hydrocarbons, including the lower-boiling hydrocarbons. Vaporized hydrocarbons are withdrawn and cooled to condense at least part of them. Some of the cooled hydrocarbons are reintroduced into the reaction zone, and some are passed to a fractionating zone. Cooled hydrocarbons in the latter zone are separated into a condensate fraction containing constituents suitable as reactants in the alkylation reaction, and a vapour fraction containing lower-boiling hydrocarbons unsuitable for this purpose. The condensate fraction is passed to the reaction zone and the vapour fraction is withdrawn.

F. H. Bruner and W. E. Skelton. U.S.P. 2,320,336, 1.6.43. Appl. 15.9.39. In the manufacture of high-anti-knock gasoline hydrocarbons by alkylation of an *iso*paraffin with C_3 and C_4 olefins in the presence of a liquid alkylation catalyst which normally causes substantial hydropolymerization of C_4 olefins, the following operations are included. A hydrocarbon fraction comprising a C_4 olefin is contacted with the liquid alkylation catalyst containing absorbed propylene, so that the C_4 olefin is absorbed under conditions avoiding substantial hydropolymerization. Afterwards absorbed olefins are contacted with an *iso*paraffin in the presence of liquid alkylation catalyst to produce desired gasoline hydrocarbons. H. B. M.

Refining and Refinery Plant.

372. Use of Chlorates in Refining High Sulphur Gasolines. N. E. Vishnevskii. *Petrol. Engr*, May 1943, **14** (8), 157.—Translated from the Russian journal *Vostochnaya Neft*, this article deals chiefly with a laboratory investigation into the use of strong oxidizing agents in the treatment of high sulphur gasolines. Difficulties arose with the gasolines obtained from the crudes of the "Second Baku" (oil-fields in Eastern European Russia brought into production during the second Five-Year Plan), and calcium hypochlorite was found much more effective than sulphuric acid and caustic soda, whilst chlorates, available cheaply in large quantities in Russia, were still better.

The respective merits of the chlorates of calcium, sodium, and potassium are discussed. The experiments were carried out in a laboratory propeller-type agitator, modelled on commercial apparatus, and are described in detail. The reagent was an acid solution of potassium chlorate. Conclusions were that :—

(1) The application of aqueous or slightly acidic solutions of chlorates is not accompanied by fire or explosion hazards.

(2) The use of chlorates in the refining of gasolines, insofar as their cost and effectiveness are concerned, is preferable to almost all existent methods, including the hypochlorite, aluminium chloride, and catalytic hydrogenation at medium pressures.

(3) Chlorate refining is inferior in effectiveness to the catalytic hydrogenation process at high pressures but is considerably cheaper and simpler.

(4) Good results are obtained with straight-run gasoline and satisfactory results with cracked gasoline. J. C.

373.* First Integrated Refinery-Cycling Plant Unit. C. C. Pryor. *Petrol. Engr*, October 1943, **15** (1), 122–130.—Plants specially designed to implement this scheme in South Texas are nearing completion. Four large cycling plants are installing additional equipment to enable recovery of *iso*butane, *n*-butane, and propane, and general descriptions of the equipment and method of operation are given. Production of the cycling plants is transported to the refinery of the Great Southern Co. near Corpus Christi, from a tank farm and pumping station operated by the Stratten Pipe Line Co., which has installed the necessary Hortonsphere tanks.

The refinery has installed an H.F. alkylation unit, a catalytic dehydrogenation unit, and a Dubbs thermo-reforming unit. *iso*Butane and *n*-butane are piped to the refinery separately from the gasoline, naphtha, etc. *n*-Butane enters the dehydrogenation unit for conversion into butylene, which, with the *iso*butane, constitutes the feed for the alkylation unit.

Debutanized distillate is de-*iso*pentanized, and the *iso*pentane blended with alkylate and straight-run aviation base stock to produce aviation gasoline.

The remainder of the distillate is split into two parts, the light fractions being used for 87 octane aviation gasoline production, and the heavier fractions are charged to the Dubbs thermo reformer for production of motor spirit. R. A. E.

374. Desulphurization of Petroleum Distillates with Zinc Hydroxide. (Translation from *Vostochnaya Neft*, 1940, 7–8.) K. A. Musatov and L. G. Krymova. *Petrol. Engr*, October 1943, **15** (1), 157–160.—Some preliminary experiments in connection with the zinc chloride process indicated that zinc hydroxide was responsible for the desulphurization noted. Further tests were carried out by contacting the vapours of products obtained from Ishimbaevo crude with pulverized and compressed hydroxide in a reactor at temperatures ranging from 200° C. to 500° C. All the untreated products possess considerable sulphur content, and the treatment effected a marked reduction in all cases.

On the laboratory scale continuous desulphurization of naphtha was achieved by contacting the vapour with an atomized solution of zinc oxide in concentrated aqueous ammonia in a reactor held at 200° C.

The expelled ammonia was recovered for re-use from a gas separator after condensation of treated naphtha. The hydroxide reacted with the sulphur compounds to yield zinc sulphide, which can be converted into oxide again by burning.

High sulphur crudes usually contain solutions of chlorides in water emulsions, and during processing much corrosion of equipment occurs, due to HCl and H_2S.

Possibilities which therefore exist in connection with the use of solid hydroxide for mitigating corrosion of equipment, reducing the sulphur content of distillate products and freeing exit gases of H_2S, are discussed, and experimental data provided. From the particular crude investigated, substantially sulphur-free gasoline and naphtha can be obtained, but kerosine and gas-oils are only partly desulphurized by the zinc hydroxide treatment. R. A. E.

375.* Continental's 100 Octane Gasoline Plant. Anon. *Petrol. Engr*, November 1943, **15** (2), 110.—The plant at Ponca City, Oklahoma, is designed to produce 5000 brl./day of high-octane aviation gasoline, and cost approximately 12 million dollars.

A T.C.C. unit for the production of base gasoline and an alkylation plant are included in the scheme, and some of the constructional details and requirements are given.
R. A. E.

376.* Wyoming Refinery for Production of Aviation Gasoline. Anon. *Petrol. Engr*, November 1943, **15** (2), 168.—The Frontier Refining Co. is installing new facilities which will more than double its crude capacity and permit the manufacture of 100 octane aviation fuel from Rocky Mountain crude.

The facilities include the following U.O.P. units: fluid catalytic cracking, H.F. alkylation, butane isomerization and thermal reforming, and provision is made for processing raw materials from nearby refineries. R. A. E.

377.* Rebuilding Tubes and Tube Headers. Anon. *Oil Gas J.*, 4.11.43, **42** (26), 53.—A procedure for rebuilding worn furnace tubes and headers by electric or oxy-acetylene welding is described. The welding should be done with a metal or alloy of the same, or better, composition. W. H. C.

378.* Baltimore Refinery Rebuilt to Produce 100 Octane Gasoline. J. P. O'Donnell. *Oil Gas J.*, 25.11.43, **42** (29), 41.—The Baltimore Refinery of the Standard Oil Company of New Jersey has been modernized, at a cost of $14,000,000, in order to produce large quantities of 100 octane gasoline. The new units include a fluid catalytic cracking unit, an alkylation unit, an atmospheric pipe-still, light ends plant, gas compression plant, and laboratory with auxiliary equipment, such as piping tankage, etc. The pipe-still produces a wide-cut gas-oil for the catalytic cracking unit, as well as naphtha for a reforming unit and residue for a vis-breaker. The catalytic cracking unit produces mainly aviation gasoline, products for the alkylation unit, light and heavy naphtha, refined oil and pitch bottoms. The compressed overhead stream constitutes the charge for the light ends unit, from which the feed for the alkylation unit is recovered. The latter uses the cold sulphuric acid process, part of the feed-stock being derived also from other cracking units. A Girbotol hydrogen sulphide scrubber and caustic washing system is also available for gas treatment. C. L. G.

379.* The Absorption Factor in Controlling the Absorption Process. R. Maas. *Oil Gas J.*, 25.11.43, **42** (29), 50.—The absorption equation derived by Alois Kremser is based on the treatment of a relatively lean gas, in which the shrinkage of volume through the absorbers, and hence the change in temperature, can be neglected. The fraction absorbed is a function of the number of equilibrium plates and of the absorption factor L/VK, where L represents mols. of oil, V mols. of gas, and K the equilibrium constant. In a specific plant the only variables which have to be taken into account, for computations of the fraction absorbed, are the oil to gas ratio and the temperature. To maintain consistent absorption, it is thus necessary to modify the oil/gas ratio with changes in absorber temperature. It is suggested that tables showing the former ratio, for the products handled, should be available to the operators. In actual practice the gas is seldom sufficiently lean enough for changes in oil and gas volumes and absorber temperatures to be negligible. In such cases the absorption factor requires recalculation, taking into account the shrinkage. It is suggested that a good enough approximation of the oil-to-gas ratio is given by the average of the lean oil to dry gas ratio and the rich oil to the mean of the top and bottom plate temperatures. In view, however, of the difficulty in metering rich gases, and the complexity of the computations involved in the more accurate method described, the lean oil to dry gas ratio can be used to give a sufficiently accurate indication of the absorption factor.

C. L. G.

380.* Industrial Control Instrument Settings. L. H. Allen. *Industr. Engng Chem.*, 1943, **35** (12), 1223.—A scientific approach to methods of setting industrial control instruments for optimum sensitivity is discussed, and it is shown that such methods result in the more rapid attainment of the optimum than by the trial and error adjustments commonly used. The employment of these scientific methods is demonstrated by a detailed discussion on the setting of a Foxboro Model 30 Stabilog temperature controller fitted to an acetone recovery column to regulate the steam flow. It is shown that the Ziegler-Nichols procedure has greater value in the establishment of optimum settings for Taylor instruments, since these are calibrated in terms of the units presented in the Ziegler-Nichols paper (*Trans. Amer. Soc. Mech. Engrs.*, **64** (8), 759–68).

The suggestion is put forward that the use of a universal system of units for the calibration of various control effects should be standardized by all instrument manufacturers.

J. W. H.

381. Patents on Refining and Refinery Plant. J. A. Chenicek. U.S.P. 2,318,196, 4.5.43. Appl. 28.7.41. Hydrocarbon distillates normally tending to form gum are stabilized by the addition of a gum inhibitor and a small amount of an amino-pyridine. The amino-pyridine increases the potency of the gum inhibitor.

W. W. Johnstone. U.S.P. 2,318,495, 4.5.43. Appl. 26.7.41. A hydrocarbon oil is treated with an alkali metal hydroxide solution containing a nitro-paraffin to reduce its sulphur content.

C. W. Berger. U.S.P. 2,318,582, 11.5.43. Appl. 28.1.42. In a refining process a hydrocarbon oil is contacted with an alkali metal hydroxide solution which has dissolved in it an alkali metal salt of a thio acid of phosphorus.

R. Lee and H. K. Holm. U.S.P. 2,319,694, 18.5.43. Appl. 6.2.41. To separate toluene from a mixture containing toluene and non-aromatic hydrocarbons of substantially similar boiling point, the hydrocarbon mixture is heated and fed to a fractionating column at a point between the ends thereof. A heated water-methanol mixture is fed to the column at a point adjacent to and below the hydrocarbon feed. A second water-methanol mixture is withdrawn as a side stream from the column at a point below the water-methanol feed. This side stream is distilled to separate methanol vapour, which is returned to the column at a point below the mixed hydrocarbon feed. Toluene is withdrawn from the column at the bottom of the exhausting section and a constant-boiling mixture of methanol and non-aromatic hydrocarbons is withdrawn from the top of the column. This mixture is condensed and water is added to extract methanol. The aqueous methanol is returned to the fractionating column as the total water-methanol feed.

J. P. Walker. U.S.P. 2,319,962, 25.5.43. Appl. 24.6.40. During the treatment of oil emulsion fluids such as flow from oil-wells, water and emulsified oil are primarily separated and a stratum of water is provided above a heated body of washing water on which a body of hot oil is collected in heat-exchange relation with the stratum of water. The process includes flowing the hot oil in a segregated path through the water stratum to cool the oil and condense liquefiable fractions in it.

E. M. Nygaard and O. M. Reiff. U.S.P. 2,320,047, 25.5.43. Appl. 24.2.41. Sulphur is removed from gasoline by reacting the sulphur compounds in the oil with a wax-substituted metal phenate and separating out the resultant reaction products.

C. A. Cohen. U.S.P. 2,320,266, 25.5.43. Appl. 27.12.39. To reduce the colour and corrosive properties of acid-treated oils, they are treated in the neutral state with the anhydrous reaction products of metallic magnesium and an organic compound possessing a replaceable hydrogen selected from the group consisting of an alcohol and a ketone.

C. A. Cohen. U.S.P. 2,320,267, 25.5.43. Appl. 29.12.39. To reduce the colour and corrosive properties of acid-treated oils, they are treated in the neutral state first with strong alkali, then with a compound having the formula $Me(X)n$, where Me is a metal selected from the group consisting of aluminium, tin, and zinc; X is a radical selected from the group consisting of alkyl, alkoxy, and alkylhalide radicals, n is a number equal to the valence of the metal radical selected.

M. C. K. Jones and R. C. Brandon. U.S.P. 2,320,277, 25.5.43. Appl. 29.10.41. During a process of sweetening hydrocarbon oils containing mercaptans which involves the dispersion of metal sulphides in the sweetened distillate product, metal sulphides are separated from the oils with the help of an aqueous dispersion of a small amount of a polysaccharide.

M. P. Matuszak. U.S.P. 2,320,629, 1.6.43. Appl. 26.5.41. To remove organic fluorine compounds from predominantly saturated hydrocarbon materials, the latter are contacted with liquid hydrofluoric acid. The resulting hydrofluoric acid extract is separated from the hydrocarbon material. The extracted hydrocarbon material is freed from a small proportion of dissolved hydrofluoric acid.

W. B. Chenault and A. E. Miller. U.S.P. 2,321,459, 8.6.43. Appl. 15.1.40. To decolorize a mineral oil, it is heated with 2–12% by weight of a decolorizing earth and 5–60% of naphtha to a temperature between 350° and 450° F. The naphtha is stripped from the heated mixture, and afterwards the earth is separated from the decolorized oil. The separated earth is reactivated by successive washings, first with naphtha, then with a colour solvent, and again with naphtha. Reactivated earth wet with naphtha from the washing treatment is used again. H. B. M.

Metering.

382. Note on the Energy and Momentum Correction Factors for Flow in Circular Pipes. K. F. Tupper. *Canad. J. Res.*, 1942, **20**, Sec. A, 195–202.—The energy and momentum correction factors are expressed as functions of two integrals depending on the velocity distribution. General relations for any stream cross-section are given for the sign and relative size of the integrals. Using the Karman–Prandtl velocity distribution laws for circular pipes, the integrals are evaluated numerically and given as functions of the bulk Reynolds number, the pipe friction factor, and other useful quantities likely to be known in practice. C. F. M.

Chemistry and Physics of Petroleum.

383. Heat Capacities at Higher Temperatures of Ethane and Propane. B. P. Dailey and W. A. Felsing. *J. Amer. chem. Soc.*, 1943, **65**, 42–44.—The determinations of the heat capacities of air, ethane, and propane from 340–700° K. are described. The results compare favourably with calculated values and with results of other investigators.

The Bonnewitz and Schulze type of adiabatic flow calorimeter used was modified to facilitate manipulation and to increase the accuracy of the results. E. H. W.

384. Heat Capacities of and Hindered Rotation in *n*-Butane and *iso*Butane. B. P. Dailey with W. A. Felsing. *J. Amer chem. Soc.*, 1943, **65**, 44–46.—Gaseous heat capacities of *n*-butane and *iso*butane have been measured over a range of 340–700° K. and have been presented tabularly and graphically. The structure of these two molecules were discussed with respect to these results. E. H. W.

385. Heats of Vaporization of some Hexanes. J. F. Lemons with W. A. Felsing. *J. Amer. chem. Soc.*, 1943, **65**, 46–48.—Results are given for densities from 0° C. to the normal boiling points and heats of vaporization from 20° C. to the normal boiling points of liquid *n*-hexane, 2-methylpentane, and 2 : 3-dimethylbutane. It was noted that the greater the branching of the chain, the smaller the heat of vaporization.

E. H. W.

386. Polyalkylbenzenes. XXXII. The Reaction between Dimethylacrylic Acid and *m*-Xylene. L. I. Smith and L. J. Spillane. *J. Amer. chem. Soc.*, 1943, **65**, 202–208.—In order to determine the limits of the rearrangement reaction previously reported in *J. Amer. chem. Soc.*, 1940, **62**, 2639, a detailed investigation of the action of various alkylated hydrocarbons upon $\beta\beta$-dimethylacrylic acid is to be undertaken.

This paper reports the results obtained with *m*-xylene. Many new compounds incidental to this work are described. E. H. W.

387. Ionization and Dissociation by Electron Impact : Butene-1. D. P. Stevenson. *J. Amer. chem. Soc.*, 1943, **65**, 209–212.—The mass spectrum of butene-1 and the appearance potentials of various ions in it are tabulated. Previous results on *iso*butylene and the butanes are briefly compared with those now given. The ionization potential of butene-1 was found to be $9{\cdot}6_5 \pm 0{\cdot}1$ e.v., and that of the vinyl radical $9{\cdot}8_7 \pm 0{\cdot}2$ e.v. The heat of dissociation of the C_2H_5–C_2H_3 bond was deduced to be $3{\cdot}3_0 \pm 0{\cdot}2$ e.v. E. H. W.

388. Ionization Constants of Aci- and Nitro-forms of some Nitroparaffins. D. Turnbull and S. H. Maron. *J. Amer. chem. Soc.*, 1943, **65**, 212–218.—Nitro-ionization constants of nitromethane, nitroethane, and nitro*iso*propane, together with aci-ionization constants of nitroethane and nitro*iso*propane, have been determined at several temperatures. The effect of substitution on the constants is discussed.

E. H. W.

389. Co-ordination of Silver Ion with Unsaturated Compounds. II. *cis*- and *trans*-2-Pentene. H. J. Lucas, R. S. Moore, and D. Pressman. *J. Amer. chem. Soc.*, 1943, **65**, 227–229.—The distribution constants K_W (between carbon tetrachloride and water) and K_D (between carbon tetrachloride and 1*N*-potassium nitrate) of *cis*-, and *trans*-2-pentene and a mixture containing 75% of the latter isomer, together with the argentation constants K_D and K_E, are tabulated. The *cis* isomer is more soluble in water and co-ordinates better with silver ion. From the results evidence is deduced confirming previously proposed resonance structures for these complexes. Observed and calculated values of K_W and K_D for the mixture of isomers agreed well, but there were discrepancies with the values of K_D and K_E. E. H. W.

390. Co-ordination of Silver Ion with Unsaturated Compounds. III. Mixtures of Trimethylethylene and *cyclo*Hexene. H. J. Lucas, F. W. Billmeyer, Jr., and O. Pressman. *J. Amer. chem. Soc.*, 1943, **65**, 230–231.—Continuing the work reported in the previous abstract, the distribution constants K_W and K_D and the argentation constants K_D and K_E of mixtures of trimethylethylene and *cyclo*hexene, are tabulated. (K_W, K_D, K_O, and K_E have the same meanings as before.) Calculated values of K_W and K_O again agreed with the observed values, but the calculated values of K_D and K_E were lower; this was suggested to be due to the fact that in aqueous salt solutions one olefin increases the solubility of another. Compositions of unknown mixtures of these two olefins, or possibly of any two olefins, may be evaluated directly from the constants K_W or K_O, or empirically from K_D or K_E of the mixture. E. H. W.

391. Addition of Metals to some Phenylated Olefins in Liquid Ammonia Solution. H. Gilman and J. C. Bailie. *J. Amer. chem. Soc.*, 1943, **65**, 267–268.—When 1 : 1-diphenylethylene in ether is added to solutions of lithium, calcium, barium, or strontium in liquid ammonia, the metals add on to the olefine link and form the corresponding coloured organometallic compounds. On ammonolysis the products all gave 1 : 1-diphenylethane and 1 : 1 : 4 : 4-tetraphenylbutane. Similarly, calcium, barium, or strontium added on to 1 : 1 : 2-triphenylethylene giving 1 : 1 : 2-triphenylethane. The significance of these experiments on the addition of the corresponding RM compounds to an olefinic link is pointed out. E. H. W.

392. Reaction of Glutarimides with Phosphorus Pentachloride. A New Pyridene Synthesis. W. W. Crouch and W. L. Lochte. *J. Amer. chem. Soc.*, 1943, **65**, 270–272.—In studies of nitrogen bases from petroleum distillates earlier workers have reported the isolation of certain compounds which appear to be β-substituted pyridenes. Attempts are now being made to find a general method for preparing these compounds. This paper reports a new synthesis of pyridene from glutarimide and phosphorus pentachloride. Pyridene homologues with halogens substituted in the nucleus were prepared similarly, starting from the corresponding glutarimides.
E. H. W.

393. Synthesis of 1-Methylnaphthalene. Note by O. Grummit and A. C. Buck. *J. Amer. chem. Soc.*, 1943, **65**, 295–296.—The synthesis with good yields, of 1-methylnaphthalene, via naphthalene, 1-chloromethylnaphthalene, and 1-naphthylcarbinylchloride is described. The density and refractive index of the product obtained are reported.
E. H. W.

394. Poly*iso*propylbenzenes. I. Preparation and Properties of Two Di-, Two Tri-, and One Tetra-*iso*propylbenzene. A. Newton, *J. Amer. chem. Soc.*, 1943, **65**, 320–323.—The preparation is described of relatively large quantities of *iso*propylbenzenes by the reaction of propene and benzene in the presence of either 96% sulphuric acid or anhydrous aluminium chloride. The products were separated by careful fractionation. Yields and constants obtained on the following are tabulated : 1 : 3- and 1 : 4-di-*iso*propylbenzene, 1 : 2 : 4-, 1 : 3 : 5-tri-*iso*propylbenzene, and 1 : 2 : 4 : 5-tetra-*iso*propylbenzene.

1 : 2 : 4-Tri-*iso*propylbenzene was isomerised to 1 : 3 : 5-tri-*iso*propylbenzene in the presence of aluminium chloride, some tetra*iso*propylbenzene being formed at the same time.
E. H. W.

395. Heat Capacity and Entropy, Heats of Transition, Fusion and Vaporization and the Vapour Pressures of *cyclo*Pentane. Evidence for a Non-planar Structure. J. G. Aston, H. L. Fink, and S. C. Schumann. *J. Amer. chem. Soc.*, 1943, **65**, 341–346.—Heat capacity measurements of solid and liquid *cyclo*pentane from 11·8° to 293·82° K. are tabulated and plotted. Equilibrium temperatures during the upper and lower transitions and the fusion are also tabulated. The two transition temperatures and the melting point are given, together with the heats of the transitions and of fusion. Vapour pressures are reported from 225·91° to 287·40° K. and values of the heat of vaporization were calculated.

The comparison of the entropies of gaseous and liquid *cyclo*pentane calculated from calorimetric and spectroscopic data was taken to indicate a symmetry number of one, and that the *cyclo*pentane molecule is non-planar, one carbon atom being out of the plane. This effect was attributed to hydrogen interactions of the type hindering internal rotation which must therefore be repulsions.
E. H. W.

396. Application of Palladium- and Platinum-Polyvinyl Alcohol-Vanadium Catalysts. L. D. Rampino and F. F. Nord. *J. Amer. chem. Soc.*, 1943, **65**, 429–431.—The preparation is described of palladium- and platinum-polyvinyl alcohol catalysts with the noble metal reduced by divalent vanadium. Experiments on the reduction by these catalysts of benzaldehyde, cinnamic aldehyde, maleic acid, and quinone are reported, and from the results it is deduced that these hydrogenations can be carried out in the absence of oxygen. Previous work on these catalysts is reported in *J. Amer. chem. Soc.*, 1941, **63**, 2745 and 3268.
E. H. W.

397. Reactions of Group IV R_4M Compounds with Silver and Copper Salts. H. Gilman and L. A. Woods. *J. Amer. chem. Soc.*, 1943, **65**, 435–437.—Contrary to previous beliefs, these authors have shown that R_4M compounds of tin and lead—*e.g.*, tetraphenyl-tin and tetraphenyl-lead—are cleaved by reaction with either silver or copper nitrates. The products vary with the R_4M compound and the inorganic salt. In the reaction between tetramethyl-lead and copper nitrate, the highly unstable methylcopper was shown to be an intermediate. Under corresponding conditions, tetraphenyl-silicon and tetraphenyl-germanium were not cleaved by silver nitrate.
E. H. W.

398. Dialkylation of Naphthalene. II. Synthesis of 2 : 6-Diphenylnaphthalene. C. C. Price and A. J. Tomisek. *J. Amer. chem. Soc.*, 1943, **65**, 439–441.—The synthesis is described of 2 : 6-diphenylnaphthalene, and it has been shown to be identical with the diphenylnaphthalene previously obtained by Pokrovskaya and Stepentseva (*J. Gen. Chem.* (*U.S.S.R.*), 1939, **9**, 1953). E. H. W.

399. Aromatic Cyclodehydration. X. 9-Alkyl- and 9 Aryl-10-phenylanthracenes. C. K. Bradsher and E. S. Smith. *J. Amer. chem. Soc.*, 1943, **65**, 451–452.—The syntheses are described of 9 : 10-diphenyl-, 9-phenyl-10-methyl-, and 9-phenyl-10-ethylanthracene, by the cyclodehydration of the corresponding *o*-benzhydrylphenones. E. H. W.

400. Preparation of Derivatives of Chrysene by means of the Robinson-Mannich base Synthesis of Unsaturated Ketones. A. L. Wilds and C. H. Shunk. *J. Amer. chem. Soc.*, 1943, **65**, 469–475.—Starting with 2-carbomethoxy-1-keto-1 : 2 : 3 : 4-tetrahydrophenanthrene, the authors have adapted the method of Robinson *et al.* (*J. Amer. chem. Soc.*, 1937, 53, and 1941, 586) to prepare the following derivatives of chrysene : 3-ketohexahydrochrysene, 2-, and 3-methylchrysene, 3-hydroxychrysene and 3-hydroxy-2-methylchrysene. Various improvements on the original method gave better over-all yields. E. H. W.

401. Addition of Triphenylmethyl to 2-Methyl-buten-1-yne-3. Note by A. F. Thompson, Jr., and D. M. Surgenor. *J. Amer. chem. Soc.*, 1943, **65**, 486–487.—An addition compound has been isolated from 2-methyl-buten-1-yne-3 and triphenylmethyl. From its reactions the compound appeared to be 4-methyl-1 : 1 : 1 : 6 : 6 : 6-hexaphenyl-hexadiene-2 : 3. E. H. W.

402. Sulphonation of Methallyl Chloride, Mobility of the Olefinic Linkage in Unsaturated Sulphonic Acids. C. M. Suter and F. G. Bordwell. *J. Amer. chem. Soc.*, 1943, **65**, 507–517.—Methallyl chloride has been sulphonated by dioxane sulphotrioxide in ethylene chloride solution at 0° C. 40% of the sulphur trioxide added to the olefin link forming a cyclic anhydride of the carbyl sulphate type, the remainder acts by substitution forming three isomeric chloro*iso*butylenesulphonic acids. With a solution of sulphur trioxide in ethylene chloride, methallyl chloride sulphonated mainly to the carbyl sulphate type of compound, but sulphonation with sodium chlorosulphonate gave a mixture of unsaturated sulphonic acids. In the presence of alkali, the olefinic link in a variety of unsaturated sulphonic acids was shown to be mobile. E. H. W.

403. Polymerization of Styrene in the Presence of 3 : 4 : 5-Tribromobenzoyl Peroxide. C. C. Price and B. E. Tate. *J. Amer. chem. Soc.*, 1943, **65**, 517–520.—Polystyrene prepared with 3 : 4 : 5-tribromobenzoyl peroxide as catalyst was found to contain bromine corresponding to about one tribromophenyl radical per polymer molecule. It was shown that these tribromophenyl groups were acquired during the course of polymerization. E. H. W.

404. Synthesis of Olefin Hydrocarbons by Catalytic Condensation and Dehydration of Aliphatic Aldehydes. V. I. Komarewsky and T. H. Kritchevsky. *J. Amer. chem. Soc.*, 1943, **65**, 547–548.—Propionaldehyde, *n*-butyraldehyde, *n*-amylaldehyde, and *n*-hexaldehyde were reacted at high pressure and temperatures between 385° and 410° C. in the presence of a chromium oxide catalyst producing pentene-2, heptene-3, nonene-4, and undecene-5, respectively.

Between 330° and 385° C. unsaturated aldehydes were formed. E. H. W.

405. Trivalent Carbon. II. Unsymmetrical Hexa-aryldimethylperoxides. E. L. Buhle, M. L. Whalen, and F. Y. Wiselogle. *J. Amer. chem. Soc.*, 1943, **65**, 584–586.—The action of oxygen on mixtures of triarylmethyl radicals generally gives predominantly the unsymmetrical hexa-aryldimethylperoxide R–O–O–R^1. E. H. W.

406. Addition of Hydrogen Fluoride to Acetylenic Compounds. A. L. Henne and E. P. Plueddeman. *J. Amer. chem. Soc.*, 1943, **65**, 587–589.—The preparation of addition compounds of hydrogen fluoride and acetylene homologues is described. Sufficient quantities were produced to allow for adequate purification. (Yields of 70–80% of the difluorides expected from Markownikow's rule being obtained.) Physical properties of the difluorides prepared are tabulated and compared with those of previous workers. E. H. W.

407. Thermal Decomposition of Hydrocarbons, Resonance, Stabilization, and Isomerization of Free Radicals. A. Kossiakoff and F. O. Rice. *J. Amer. chem. Soc.*, 1943, **65**, 590–595.—From a theoretical consideration of the resonance energies of different radicals it is shown that secondary radicals are stabilized by twice, and tertiary by three times, the resonance energy of a primary radical. This is probably responsible for the observed difference in rates of removal of primary, secondary, and tertiary hydrogen atoms. The relative rates of decomposition of radicals from the decomposition of paraffin hydrocarbons are calculated and used to predict the products of decomposition of hexanes, heptanes, and octanes, giving agreement with observed results. E. H. W.

408. Carbides of Magnesium. W. H. C. Rueggeberg. *J Amer. chem. Soc.*, 1943, **65**, 602–607.—The preparation of magnesium carbide Mg_2C_3 is described, and X-ray powder photographs were obtained. On hydrolysis methyl acetylene was produced. From the results Mg_2C_3 appears to be a pure substance. Magnesium acetylide, MgC_2, was prepared from magnesium diethyl and acetylene. An explanation is proposed for the observed instability and reactivity of MgC_2. E. H. W.

409. Utilization of Aliphatic Nitro Compounds. VIII. Nitrotriols (Nitroglycerols) Prepared from Simple Aldehydes. C. A. Sprang with E. F. Degering. *J. Amer. chem. Soc.*, 1943, **65**, 628.—Nitrotriols are prepared by condensing two equivalents of formaldehyde with one equivalent of a higher aldehyde and one of nitromethane. This preparation of nitrotriols is similar to that of nitrodiols, but the purification of the former is much simpler. E. H. W.

410. Condensation of Unsaturated Amines with Aromatic Compounds. The Preparation of β-substituted Phenethylamines. A. W. Weston, A. W. Ruddy, and C. M. Suter. *J. Amer. chem. Soc.*, 1943, **65**, 674–677.—A new method of preparing β-substituted phenethylamines by condensing unsaturated amines with aromatic compounds in the presence of aluminium chloride is described. A number of allylamine derivatives have been prepared. E. H. W.

411. Normal Addition of Hydrogen Bromide to 3-Butenoic, 4-Pentenoic, and 5-Hexanoic Acids in Hexane. A. Michael and H. S. Mason. *J. Amer. chem. Soc.*, 1943, **65**, 683–686.—Hydrogen bromide adds normally to 3-butenoic, 4-pentenoic, and 5-hexanoic acids in hexane solution, oxygen being carefully excluded. E. H. W.

412. Studies of Sulphonates. VII. Conductances and Densities of Sodium Ethyl-*n*-Butyl-, *n*-Octyl-, and Dodecylbenzene-*p*-sulphonate Solutions. R. G. Paquette, E. C. Lingafelter, and H. Y. Tarter. *J. Amer. chem. Soc.*, 1943, **65**, 686–692.—The preparation and description is given of caprylyl chloride, *n*-heptyl-phenylketone, and the new compounds, sodium *n*-octylbenzene-*p*-sulphonate, *n*-dodecylbenzene, sodium *n*-dodecylbenzene-*p*-sulphonate, and aniline *p*-sulphobenzoate. A method for determining the position of the sulphonate group is outlined. Conductances and densities are tabulated for solutions of ethyl-, *n*-butyl-, *n*-octylbenzene *p*-sulphonates, and mixed *ortho*- and *para*-*n*-octylbenzene sulphonates at 25, 40, and 60° C., and at 60° C. only for dodecylbenzene-sulphonate. The benzene ring is shown to be equivalent to about three and one-half straight-chain carbon atoms in its effect on the critical concentration for micelle formation, but neither length nor number of carbon atoms in the aromatic compound appear to control the effect which seems to be specific to the benzene nucleus. E. H. W.

413. Electrolytic Properties of Solutions of Paraffin-Chain Quaternary Ammonium Salts. A. B. Scott and H. V. Tarter. *J. Amer. chem. Soc.*, 1943, **65**, 692–698.—Equivalent conductances and densities at 25°, 40°, and 60° C. are tabulated for aqueous

solutions of decyl-, dodecyl-, hexadecyl-, butyl-, hexyl-, and octyl-trimethylammonium bromides. The four highest members of the series gave evidence of micelle formation. In a cell specially developed for the purpose, conductances of hexyltrimethylammonium bromide and sodium ethylbenzene-*p*-sulphonate were measured at very low concentrations. The results are discussed with regard to existing theories.
E. H. W.

414. Electrolytic Properties of Aqueous Solutions of Octyltrimethylammonium Octanesulphonate and Decyltrimethylammonium Decanesulphonate. A. B. Scott, H. V. Tarter, and E. C. Lingafelter. *J. Amer. chem. Soc.*, 1943, **65**, 698–701.—The preparations of octyltrimethylammonium octanesulphonate and decyltrimethylammonium decanesulphonate are described, and the equivalent conductances measured at 25° C. These two salts form micelles (which appear to have an electric charge of 1–2), at concentrations much below that for long-chain salts. E. H. W.

415. Kinetics of Polymerization Reactions. I. First Order Initiation Reaction. R. Ginell and R. Simha. *J. Amer. chem. Soc.*, 1943, **65**, 706–715.—A critical discussion of the methods used in the treatment of polyreactions is given. A theory of chain polymerization reactions is developed which contains as parameters three constants, the rate of creation of active nuclei, their velocity of growth, and the rate of breaking of the growing chains. The last two steps are assumed to be second-order reactions between the active chains and the stable monomer. Limitations are pointed out. The dependence of the course of the reaction, of the final average chain length, and of the chain length distribution on the rate constants, in particular on the rate of initiation and on the initial concentration, are shown. Two limiting cases can be distinguished. If the ratio between the rate of cessation and that of initiation is large, and the ratio of the rate of propagation and that of cessation is also large, then the average molecular weight will be large at the end and remain approximately constant during the last stages. If these ratios are small, then the average molecular weight will increase continuously and reach a small final value. It is shown how the individual rates may be derived from a knowledge of these quantities. The theory of Schulz, and Norrish's and Brookman's results, appear as special cases. C. F. M.

416. Kinetics of Polymerization Reactions. II. Second and Combined First and Second Order Initiation Reactions. Mutual Stabilization of Growing Chains. R. Ginell and R. Simha. *J. Amer. chem. Soc.*, 1943, **65**, 715–727.—The considerations of the previous paper (see preceding abstract) are extended to second-order initiation of monomer. Again two limiting cases are found. A comparison of this case with the previous one shows that second-order initiation gives rise to a product with a smaller final average molecular weight. Only if the rate of initiation is vanishingly small do the results become identical. No dependence of the final mean chain length on the initial concentration is found. The effect of the mutual termination of growing chains on the final average molecular weight and the size distribution is considered in an approximate manner. Possible extensions of this theory are pointed out. C. F. M.

417. Condensation of Amino Alcohols with Benzene. C. M. Suter and A. W. Ruddy. *J. Amer. chem. Soc.*, 1943, **65**, 762–763.—Amino alcohols containing a tertiary hydroxyl group condense with benzene in the presence of excess aluminium chloride to give $\beta\beta$-dialkylphenethylamine derivatives. T. C. G. T.

418. Petroleum Acids. V. Aliphatic Acids from Californian Petroleum. W. A. Quebedeaux, G. Wash, W. O. Ney, W. W. Crouch, and H. L. Lochte. *J. Amer. chem. Soc.*, 1943, **65**, 767–770.—Californian petroleum acids have been fractionated by distillation and purified by esterification with methanol. The acids were then liberated, dried, and again esterified. This treatment removed all hydrocarbons and phenols.

A study of the 720 fractions obtained, particularly boiling point and refractive index, has led to the isolation and identification of the following aliphatic acids: 2- and 3-methylpentanoic; *n*-hexanoic; 2-, 3-, 4-, and 5-methylhexanoic, *n*-heptanoic, *n*-octanoic, and *n*-nonanoic. T. C. G. T.

419. Petroleum Acids. VI. Naphthenic Acids from Californian Petroleum. W. O. Noy, W. W. Crouch, C. E. Rannefeld, and H. L. Lochte. *J. Amer. chem. Soc.*, 1943, **65**, 770–777.—Refractive indices on the 720 methyl esters referred to in an earlier paper (Abstract No. 418) indicated the occurrence in certain fractions of naphthenic acid and five have been isolated and identified for the first time from petroleum. They are, 2-methyl*cyclo*pentanecarboxylic, 3-methyl*cyclo*pentanecarboxylic, 2 : 3-dimethyl*cyclo*pentaneacetic, *cyclo*hexanecarboxylic and *cis*-2 : 2 : 6-trimethyl*cyclo*hexanecarboxylic acids. *cyclo*Pentanecarboxylic, *cyclo*pentaneacetic, and 3-methyl*cyclo*pentaneacetic acids were also isolated, but these have already been reported in European petroleum by Nenitzescu. T. C. G. T.

420. Geometric Isomers of Piperylene. D. Craig. *J. Amer. chem. Soc.*, 1943, **65**, 1006–1013.—*cis*- and *trans*-Piperylene have been isolated from fractions of the C_5 cut of a petroleum pyrolyzate by the formation and subsequent decomposition of the cuprous chloride addition compounds. The *cis*-configuration was assigned to the higher-boiling isomer from its slow reactions with maleic anhydride and sulphur dioxide. 1 : 2 : 3 : 4-Tetrabromopentane formed from either isomer, on debromination gave a mixture of approximately equal parts of the two isomers. *cyclo*Pentene was shown to form a minimum boiling mixture with *cis*-piperylene. From the results it is argued that the most probable structure for the *cis* isomer is the " chair " form, while *trans*-piperylene appears to react largely in the " boat " form. E. H. W.

421. Catalytic Hydrogenation of Benzene over Metal Catalysts. P. H. Emmett and N. Skau. *J. Amer. chem. Soc.*, 1943, **65**, 1029–1035.—Previous work on a series of iron-cobalt catalysts was confirmed, and it was shown that iron was inactive, although having a surface area as large as very active cobalt catalysts. Copper catalysts with traces only of nickel were inactive below 200° C., the surface areas being many times larger than the very active cobalt catalysts. With small amounts of nickel the copper was slightly active at 200° C. Palladium-silver alloys had activities which decreased markedly with a decreasing palladium content. Chemisorption of carbon monoxide and carbon dioxide on nickel and copper was studied in an attempt to discover something of the mechanism of the promoter action of nickel in copper.

The authors deduce that a necessary but not sufficient requirement for a low-temperature metal catalyst for hydrogenating benzene, is that the metal should have dimensions and configurations falling within the " square of activity " of Bolandin's hypothesis (*Z. physik. Chem.*, 1929, *B2*, 289). E. H. W.

422. Synthesis and Rearrangement of Some Decahydro- and Tetrahydro-naphthalenediols. J. English, Jr., and G. Cavaglieri. *J. Amer. chem. Soc.*, 1943, **65**, 1085–1089.—The preparation is described of *cis*- and *trans*-methyldecahydronaphthol-1 from which were derived, 1-methyl-1 : 2-*trans*-dihydroxy-*trans*-decahydronaphthalene trihydrate and the corresponding 1 : 9-*trans*-dihydroxy-compound, the latter being anhydrous. The structure of these glycols was proved by cleavage with lead tetra-acetate, and their rearrangements were also studied. Similar experiments carried out in the tetrahydronaphthalene series showed that their reactions were unlike the corresponding decahydronaphthalene derivatives. E. H. W.

423. Catalytic Dehydrogenation of 2-Substituted-5 : 6 : 7 : 8-tetrahydronaphthalene Derivatives. M. S. Newman and H. V. Zahm. *J. Amer. chem. Soc.*, 1943, **65**, 1097–1101.—The preparation and dehydrogenation over a 20% platinum on charcoal catalyst of twelve 2-substituted-5 : 6 : 7 : 8-tetrahydronaphthalene derivatives are described. From the results three generalizations are postulated: (1) the carbomethoxy group is not affected by hydrogen under the conditions of these experiments. Thus the methyl esters $C_{10}H_{11}(CH_2)_nCOOCH_3$ where $n = 0, 1, 2$, and 3 were converted in high yields to the corresponding naphthalene derivatives, the theoretical amount of hydrogen being evolved. (2) The ketonic carbonyl group adjacent to the aromatic nucleus is reduced to a methylene group. (3) A carbon–oxygen single bond adjacent to the aromatic nucleus is hydrogenolyzed. E. H. W.

424. Raman Spectra of Four Pairs of *meso*- and *dl*-Disubstituted Butanes. H. F. Taufen, M. J. Murray, and F. F. Cleveland. *J. Amer. chem. Soc.*, 1943, **65**, 1130–

1134.—The Raman spectra of the following diastereomers are reported: *meso*- and *dl*-2 : 3-butanediol, *meso*- and *dl*-2 : 3-diacetoxybutane, *meso*- and *dl*-2 : 3-dibromobutane, and *meso*- and *dl*-2 : 3-dichlorobutane. Distinct differences, well above experimental error have been observed in the spectra of each pair. Where possible the purity of each isomer was estimated from the spectra. The presence of rotational isomers in the halogenated butanes was indicated and a correlation of the rotational possibilities with the spectra and dipole moment data is pointed out. E. H. W.

425. Model Experiments on the Use of *cyclo*Pentadiene in the Synthesis of Sterol-like Compounds. Note by C. F. Koelsch and F. J. Lucht. *J. Amer. chem. Soc.*, 1943, **65**, 1240–1242.—*cyclo*Pentadiene would not react, under any of the conditions tried, with 3-methyl*cyclo*hexanone, but 1 : 1-addition products were readily obtained with either phenylquinone or 2-*cyclo*hexyl-5-methylquinone and *cyclo*pentadiene. E. H. W.

426. Catalytic Degradation of Heptaldehyde in Vapour Phase. Note by T. J. Suen and S. Fan. *J. Amer. chem. Soc.*, 1943, **65**, 1243–1245.—Heptaldehyde has been pyrolyzed at 250° C. in the presence of a nickel catalyst. The products contained *n*-hexane, a considerable amount of unsaturated hydrocarbons, some *n*-heptyl alcohol and other higher boiling products. Reaction processes to account for the products are suggested. See Abstract No. 873, 1943. E. H. W.

427. Preliminary Examination of Some Turner Valley Crude Oils. W. G. May, K. A. Miners, and J. W. T. Spinks. *Can. J. Res.*, 1943, **21** (4), 73–79.—Crude oil from eight wells in Turner Valley have been distilled through Stedman columns, and graphs are presented plotting b.pt./volume distilled, refractive index/b.pt., and specific refractivity/b.pt. The results shown deal with the gasoline fractions and the probable hydrocarbon constituents are suggested. T. C. G. T.

428. Mercury Photosensitized Decomposition of *n*-Butane. A. W. Hay and C. A. Winkler. *Canad. J. Res.*, 1943, **21** (8), 149–155.—The mercury photosensitized decomposition of *n*-butane at 100° C., 175° C., and 250° C. is described and the results tabulated. The main products at all temperatures studied are, hydrogen, octanes, and dodecanes, from which it was deduced that the primary step was a C–H bond split forming butyl radicals, followed by radical combination reactions. The various mechanisms possible are discussed, and the corresponding decomposition of propane is compared with the one now reported. E. H. W.

429. The Physical States of Anhydrous Sodium Soaps. W. Gallay and I. E. Puddington. *Canad. J. Res.*, 1943, **21**, Sec. B, 202–210.—Density measurements and differential cooling curves have been carried out on sodium stearate and sodium oleate over a range of temperatures. For sodium stearate the genotypical or unidimensional melting point at 70° C. found by Thiessen *et al.* has been corroborated. A large transition has been noted at about 100° C., and it is suggested that this phase transition is due to a melting in a second dimension at right angles to the molecular axis. A further large transition has been found at 125–130° C. leading to a plastic state in the soap, and it is suggested that this transition point denotes the essential completion of bidimensional melting of the lattice and probably accounts for the sudden change in viscosity of suspensions of sodium stearate in mineral oils at about 120° C. No further considerable phase change was found up to about 200° C., when disruption of the polar bonds probably occurs to effect complete disruption of the lattice to the liquid crystalline state. Only the latter transition point was found for sodium oleate at about 135° C. C. F. M.

430. The Effect of Certain Addition Agents on the Physical States of Sodium Soaps. W. Gallay and I. E. Puddington. *Canad. J. Res.*, 1943, **21**, Sec. B, 211–218.—The effect of glycerol and of polar and non-polar mineral oils on the density–temperature relations of sodium stearate and sodium oleate have been measured. A non-polar solvent such as a high V.I. oil has no effect, and may be regarded as an inert diluent.

Glycerol and low V.I. oils also have no effect up to the unidimensional melting point of the soap. Above this point, however, an increasing effect is obtained both with increase in temperature and with amount of solvent. The effect is particularly marked above the plasticity point, but may be large also in the region of the bidimensional melting point of the soap. The orienting effect of the non-polar hydrocarbon chain on the polar grouping of the soap in the presence of a polar solvent is discussed. The influence of excess acid and alkali in the soap is described. C. F. M.

431. Aromatics in Turner Valley Crudes. L. Hendrickson, A. T. Hutcheon, and J. W. T. Spinks. *Canad. J. Res.*, 1942, **20**, Sec. B., 231–239.—Using a specific dispersion method the authors have determined benzene, toluene, and xylenes in seven Turner Valley crude oils. Benzene varies from 0·33% wt. to 0·63% wt., toluene from 1·30% to 2·18%, and xylenes from 1·71% to 2·71%. There does not appear to be any relationship between aromatic content and the position in the field. T. G. C. T.

432. Reaction of Hydrogen Atoms with *iso*Butane. W. H. White, C. A. Winkler, and B. J. Kenalty. *Canad. J. Res.*, 1942, **20**, Sec. B., 255–264.—The reaction of hydrogen atoms with *iso*butane has been investigated by the Wood–Bonhoeffer discharge tube method over a temperature range 30–250° C. An activation energy of 10·5 ± 1·5 kg. cal. was obtained for the reaction.

The nature of the products at a given temperature depends on the concentration of hydrogen atoms present. With low atom concentration (5–9%) methane was the main product at temperatures below 170° C. At 250° C. ethane was formed to the extent of approximately half the amount of methane. With 14–24% concentration ethane was formed in appreciable quantities at 140–170° C., and exceeded the methane content at 250° C. Small amounts of propane were formed at the higher temperatures.

T. C. G. T.

433.* Kinetics of Aromatic Halogenation. Part I. Bromination. P. W. Robertson, P. B. D. De La Mare and W. T. G. Johnston. *J. chem. Soc.*, 1943, 277.—Bromination of acetanilide, aceto-*p*-toluidide, mesitylene, anisole, and *p*-tolyl methyl ether in acetic acid at 24° C., with concentrations in the region M/40, showed third-order kinetics. In the region M/1000 the acetanilide reaction changed to one of second order, with a corresponding increase in the heat of activation. Addition of water increased the rate and caused a gradual change to a bimolecular reaction. Chloroform or carbon tetrachloride additions decreased the rate at first, but with further additions the reaction changed to an order greater than three and became light sensitive, which was taken to indicate the initiation of chain reactions. The formal similarity between these aromatic brominations and the addition of bromine to an olefinic compound is pointed out. Possible mechanisms for the reactions are discussed. E. H. W.

434.* Kinetics of Aromatic Halogenation. Part II. The Chlorination of Hydrocarbons. P. B. D. De La Mere and P. W. Robertson. *J. chem. Soc.*, 1943, 279–281.—Rates of chlorination of benzene and naphthalene, together with heats of activation, have been measured in acetic acid solution. In the series, methyl-, ethyl-, *iso*propyl-, tertiary butyl benzene the relative rates of chlorination were in the order 100, 84, 51, 32, showing evidence of alkyl conjugation. The halogenation rates of a series of methyl benzenes from toluene to pentamethyl benzene were examined, the latter compound had a rate of halogenation 4 × 10^9 that of benzene, per replaceable hydrogen atom. E. H. W.

435.* Catalytic Reduction by Formic Acid under Pressure. Part II. A Comparison of Copper and Nickel as Catalysts. R. R. Davis and H. H. Hodgson. *J. chem. Soc.*, 1943, 281–282.—Using an apparatus previously described (*J. chem. Soc.*, 1943, 85), benzaldehyde, benzoic acid, and nitrobenzene were reacted under pressure with formic acid in the presence of a copper catalyst giving benzyl alcohol and toluene, benzene, and aniline respectively. Under similar conditions, but using a nickel catalyst, nitrobenzene and phenol were reduced to *cyclo*hexylamine and *cyclo*hexanol, respectively. Copper catalysts promoted non-nuclear reduction of aromatic compounds, but nickel promoted nuclear reduction. E. H. W.

436.* Catalytic Dehydrogenation of Alcohols to Aldehydes in the Presence of Air. R. R. Davis and H. H. Hodgson. *J. chem. Soc.*, 1943, 282–284.—Butyl, dodecyl, and benzyl alochols were dehydrogenated by passing their vapours mixed with air over a catalyst. Of the four catalysts tried, copper-silver on pumice was found to be the best. A definite air/alcohol ratio for maximum yield of aldehyde appeared to be specific for each alcohol, being well below the theoretical amount of oxygen required in each case. The aldehyde produced was comparatively pure, the main by-product (present in small quantities) being the corresponding carboxylic acid. The mechanism suggested for the reaction involves catalytic oxidation by the air alongside catalytic dehydrogenation of the alcohol to aldehyde and hydrogen. E. H. W.

437.* Rubber, Polyisoprenes and Allied Compounds. Part V. The Chemical Linking of Rubber and of Other Olefins with Phenol-Formaldehyde Resins. J. I. Cunneen, E. H. Farmer, and H. P. Koch. *J. chem. Soc.*, 1943, 472–476.—Rubber, *iso*prenic olefins, and doubtless most olefinic substances combine in virtue of their unsaturation with the condensation products of phenol and formaldehyde to give chroman derivatives. The detailed structure of the combination products, the relation of chroman-formation to the formation of phenol-formaldehyde resins, and the significance of certain ancillary features of the reaction are discussed. C. F. M.

438. Plastics from Acetylene. J. I. Jones. *Chem. and Ind.*, 1943, 62, 66–71.—A general review outlining the production starting from acetylene, of many basic raw materials for the manufacture of plastics.

Among the more important preparations mentioned are: acetaldehyde, acetic acid, acetic anhydride, acetone, acrylic and methacrylic acids, together with materials used in production of synthetic rubber and textile fibres, synthetic drying oils and polymerizable polyvinyl compounds. E. H. W.

439. Mechanism of Catalytic Hydrogenation. E. K. Rideal. *Chem. and Ind.*, 1943, 62, 325–328.—The author gives a critical survey of the knowledge accumulated on catalytic hydrogenation since the time of Sabatier. The various methods employed in deducing the nature of hydrogen layers on catalysts are outlined. The *ortho-para* hydrogen conversion was investigated and used as an indicator for chemisorbed hydrogen atoms. Deuterium exchange reactions of ethylene and propylene, and the reaction between hydrogen and butene-1 were examined. The mechanism proposed to explain these reactions assumes that the olefin is chemisorbed by the opening up of the double bond and attachment of the olefin to neighbouring nickel atoms. Similar reaction mechanisms are outlined for the cyclization of *n*-heptane and *n*-octane, and the Fischer–Tropsch synthesis of hydrocarbons. The author states that whilst these mechanisms are not certain, evidence so far obtained favours the suggestion of two-point contact on the catalyst and the addition of an undissociated molecule of hydrogen in a single step. Industrial implications of these theories are also pointed out. E. H. W.

440.* High-Pressure Absorption of Low-Boiling Hydrocarbons. C. G. Kirkbride and J. W. Bertetti. *Industr. Engng Chem.*, 1943, 35 (12), 1242.—Equilibrium constants have been determined for methane, ethane, propane, *n*-butane, and *n*-pentane in three types of absorption oil over the pressure range 125–3100 p.s.i. at a temperature of 85° F. The experimental procedure is described, and the absorbing oils used were of paraffinic, naphthenic, and aromatic type. The data are presented in the form of graphs showing the variation in equilibrium constant with pressure for each type of absorption oil. It is shown that at low pressures a paraffinic type lean oil is preferable, since substantially less volume is required for the same amount of pentane absorption, and the methane absorption for the same pentane recovery is the same for each of the three types of lean oils. At high pressures the aromatic and naphthenic lean oils have a substantial selectivity for pentane absorption with respect to methane, compared with that obtained for a paraffinic lean oil. At pressures above 1500 p.s.i. the naphthenic lean oils absorb less methane than the paraffinic, and at pressures above 1750 p.s.i. the aromatic type absorb less methane than the naphthenic. J. W. H.

441.* Correlating Adsorption Data. D. F. Othmer and F. G. Sawyer. *Industr. Engng Chem.*, 1943, **35** (12), 1269.—Methods of plotting and using data for the design of adsorption systems are presented which are of particular value when only a small amount of data is available. It is shown that the most useful plot is that of the isoteres which represent a comparison of the vapour pressure of the substance at different temperatures when the concentration of the adsorbable substance is kept constant. Full instructions are given for the preparation of a plot of this type. The Freundlich isotherms are not straight, but the isoteres are linear. From the slope of the isoteres it is possible to calculate the instantaneous heat of adsorption, and it is shown that the relationship between the heats of adsorption and concentration is linear except at low adsorbate concentrations for a certain group of compounds, but that in other compounds a gradual change of the heat of adsorption with concentration takes place. A comparison is made of the calculated and experimentally determined integral heats of adsorption. From this correlation it is shown that the plot of the instantaneous heats is correct, since the calculated values are in most cases in good agreement with the experimental results. J. W. H.

442.* Viscosity of *n*-Pentane. R. H. Hubbard and G. G. Brown. *Industr. Engng Chem.*, 1943, **35** (12), 1276.—The viscosity of *n*-pentane has been determined with a rolling ball viscometer at pressures up to 1000 p.s.i. over the temperature range 25–250° C. with an accuracy of 5% up to 150° C. and 10% at higher temperatures. The data are correlated in graphical form and a comparison is made of the present results with those previously published. At normal temperatures good agreement with previously published determinations is shown, but at higher temperatures divergencies as high as 18% exist. The pressure coefficient for the viscosity of pentane was found to be 50–70% higher than that indicated by Sage and Lacey. J. W. H.

443.* Heat Capacities of Hydrocarbon Gases (correspondence). D. R. Stull. *Industr. Engng Chem.*, 1943, **35** (12), 1303.—In a recent paper by Stull and Mayfield (*Industr. Engng Chem.*, 1943, **35**, 639) the heat capacities of a large number of hydrocarbons at zero pressure were presented. These data have now been converted to heat capacities at 1 atmosphere pressure by means of the Berthelot equation of state, and the values at this pressure are presented for the temperature range 250–1500° K. J. W. H.

444.* Definitions For Waxes, etc., Derived From Petroleum. Anon. *J. Inst. Petrol.*, December 1943, **29** (240), 361–363. *Report by the Nomenclature Panel of Standardization Sub-Committee No. 8.—Petroleum Waxes.* Definitions for petroleum wax, slack wax, oil in wax, scale wax, refined paraffin wax, petrolatum wax, petroleum jelly or petrolatum, and petroleum ceresin group are given. A. H. N.

Analysis and Testing.

445. New Technique for the Ultimate Micro-analysis of Organic Compounds. R. Belcher and C. E. Spooner. *J. chem. Soc.*, 1943, 313–316.—The apparatus conforms to normal micro-combustion technique, but combustion is effected at 800° C. by a rapid stream of oxygen (50 mls. per min.) in a tube containing no catalyst or contact material. Carbon and hydrogen are determined gravimetrically, and a silver gauze at the exit end of the tube absorbs acid gases. Water extraction of the silver sulphate gives the sulphur. The copper spiral or the lead peroxide methods for removing oxides of nitrogen have been found unsuitable for this particular technique, and are replaced by the Elving and McElroy absorbers (*i.e.*, N/50 potassium permanganate in conc. sulphuric acid or a saturated solution of potassium dichromate in sulphuric acid). Sulphur can also, of course, be absorbed and determined titrimetrically in the same manner as halogens. T. C. G. T.

446. Liquid Flow at Small Constant Rates. R. O. King and R. R. Davidson. *Canad. J. Res.*, 1943, **21**, Sec. A, 65–67.—A " Microdoser " is described by means of which very small rates of flow of liquid (of the order of 0·002 gm. per min.) can be obtained. The liquid is displaced from a reservoir by the gas evolved from an electrolytic cell at a rate directly proportional to the current flowing. C. F. M.

447. Quantitative Analysis by Mass Spectrometry. O. L. Roberts. *Petrol. Engng*, May 1943, **14** (8), 109.—It is claimed that the mass spectrometer in use in the laboratory of the Atlantic Refining Co. is the first commercial instrument capable of quantitative analysis of complicated mixtures. Hydrocarbon samples containing a dozen components have been satisfactorily analysed, but at present the application of the instrument is limited by lack of the pure compounds necessary to calibrate it. It is predicted that when the full range can be utilized, the mass spectrometer will be the most useful analytical tool available for hydrocarbon analysis, and should be suitable for plant-control purposes, whilst in some simple cases it could be made to operate plant adjustments automatically. Another important application is in the elucidation of reactions—*e.g.*, the alkylation reaction can be investigated by using heavy hydrogen as a tracer element and determining its presence or absence in the reaction products.

The theory of the mass spectrometer is explained and the principles of construction of the commercial instruments outlined. An electron cloud is produced by means of a metallic filament and attracted to a positively charged electrode. The electron stream is defined by a slit in this electrode, and then meets the gas under analysis, when collision of the electrons with the gas molecules produces a variety of positively charged ions. These are attracted towards two negative electrodes, which increase their velocity. The ions pass through slits in these electrodes and enter the semicircular analyser tube, where they are deflected by an externally applied magnetic field. Ions of a given mass will undergo the same deflection. By suitably adjusting the magnetic field strength and the potential of the negatively charged accelerating electrodes, the stream of ions will acquire the proper radius of curvature to impinge on the collector plate, the changing potential of which is automatically recorded by an amplifier and recording oscillograph. In actual practice the magnetic field strength is kept constant and the potential of the accelerating electrodes automatically adjusted to bring into focus in turn each stream of ions of different mass. About one-tenth of 1 ml. of gas sample is sufficient for analysis.

The interpretation of the spectra obtained is discussed and typical analytical results are quoted. J. C.

448.* Development in Analysis of Hydrocarbon Gases by Adsorption Fractionation. Nelson C. Turner. *Oil Gas J.*, 29.4.43, **41** (51), 48. See *Refiner*, May 1943, **22** (5), 140 (*J. Inst. Petrol.*, 1943, **29** (239), 415 A, Abstract No. 1084). C. G. G.

449.* Correlation of I.P. Lovibond and Saybolt Chromometer Colour Measurements on Motor Fuels and Refined Petroleum. Anon. *J. Inst. Petrol.*, December 1943, **29** (240), 357–360. *Report by the Colour Panel of Standardization Sub-Committee* 3.—*Liquefied Petroleum Gases, Gasoline, Kerosene, and Light Distillates.* Correlation of the two tests are presented, together with a curve. A. H. N.

Synthetic Products.

450.* Chloro-Hydrocarbon Solvents. E. W. McGovern. *Industr. Engng Chem.*, 1943, **35** (12), 1230.—A comprehensive correlation of the physical properties of the more important chlorinated aliphatic hydrocarbon solvents, including methylene chloride, chloroform, carbontetrachloride, trichlorethylene, perchlorethylene, ethylene dichloride and propylene dichloride is presented, and in addition a discussion is given on the inflammability, stability, toxicity, selective solvent action, and effect on common engineering metals. J. W. H.

451.* Synthetics for the Petroleum Industry. E. A. Evans. *J. Inst. Petrol.*, December 1943, **29** (240), 333–356.—A detailed compilation of the patent literature on the subject, with 140 references, is presented, followed by a discussion. A. H. N.

452.* New Synthetic Oil Processes in Germany. Anon. *Petrol. Times*, 8.1.44, **48**, 28.—Such information as is available of the work of Professor Fischer and the Kaiser Wilhelm Institute indicates that (1) gas for the synthetic process can be advantageously produced from methane by treatment with steam and/or carbonic acid. (2) Much attention has been given to the development of new catalysts for the Fischer–Tropsch synthesis and to the effects of variation of catalyst and operating conditions on the yield and nature of products obtainable. Some details are given for nickel, cobalt iron and ruthenium catalysts. (3) A method of direct synthesis, known as "Isosynthesis" has been developed with a view to producing fuels of high antiknock value. A fuel whose C_4 fraction contains 90% of *iso*butane has been obtained. (4) Isomerization of *n*-paraffins available from synthetic oil fractions has been developed.

Future possibilities of the synthetic processes are discussed. R. A. E.

453. Patent on Synthetic Products. J. A. South. U.S.P. 2,320,106, 25.5.43. Appl. 7.8.40.—Used oil is purified by contacting it with a treating agent containing a substance of the group consisting of oleo-resins and gum resins. After treatment, sludge, other contaminants, and the special agent are separated from the oil. H. B. M.

Motor Fuels.

454. Patents on Motor Fuels. G. Egloff. U.S.P. 2,318,765, 11.5.43. Appl. 10.6.40. In the production of anti-knock motor fuel, hydrocarbons are subjected to conversion to produce *iso*butane. The resultant products are fractionated and a liquid *iso*butane fraction is obtained. Simultaneously, normally gaseous paraffins are dehydrogenated to convert a substantial portion of them into normally gaseous olefins. Gaseous products of the dehydrogenation process are fractionated in counter-current contact with the liquid *iso*butane fraction under conditions designed to form a liquid mixture. Finally this mixture is alkylated to react normally gaseous olefins with *iso*butane.

C. C. Sperling. U.S.P. 2,319,354, 18.5.43. Appl. 31.10.40. In a vapour-phase cracking system in which a gaseous hydrocarbon heat carrier is mixed with and utilized for the cracking of a stream of heated sulphur-bearing hydrocarbon vapours, the sulphur content of the end product is kept low in the following way. A high ratio of gaseous heat carrier to hydrocarbon vapours is maintained during cracking. Cracked products are cooled and fractionated, and both liquid and gaseous constituents of the cracked products are contacted with a sulphide removing agent. This agent and the sulphides are removed from the cracked products and heat carrier gas, having a sulphur content sufficiently low to promote formation of removable sulphides from the heated sulphur-bearing vapours, is separated from the cracked products. A motor fuel end-product is finally obtained from the liquid products.

H. W. Grote. U.S.P. 2,319,500, 18.5.43. Appl. 18.4.40. Hydrocarbon oils can be converted into valuable products, including high anti-knock motor fuel, in the following way. A combined feed is subjected to the action of a powdered aluminium chloride catalyst in a primary cracking zone. The reactionary products are passed to a primary flashing zone. Vapours from this zone are directed to a fractionating column for separation into normally gaseous products, gasoline-boiling-range hydrocarbons, and higher-boiling intermediate conversion products. Some of these conversion products are subjected to the action of powdered aluminium chloride in a secondary cracking zone. Products from this zone are mixed with products from the primary cracking zone for joint flashing. Non-vaporous products containing aluminium chloride are withdrawn from the primary flashing zone to a secondary flashing zone for further vaporization. The vapours containing aluminium chloride are scrubbed with raw oil charging stock to form the combined feed for the primary cracking zone and to condense the aluminium chloride in the vapours.

E. C. Pitzer. U.S.P. 2,319,948, 25.5.43. Appl. 5.7.40. Hydrocarbon oils are converted into gasoline of high knock rating by contacting the oil vapours at conversion temperatures with a catalyst consisting essentially of titanium oxide in the form of a gel and from 10% to 40% of aluminium oxide.

C. L. Brown. U.S.P. 2,321,280, 8.6.43. Appl. 7.12.38. A safety fuel boiling between 300° and 400° F., and having a flash point of at least 100° F. by the closed-cup method, consists predominantly of the paraffinic compounds formed by the reaction between *iso*butane and a C_4 olefin. The fuel contains sufficient of an anti-knock agent to bring its octane number to about 100.

A. Y. Mottlau and P. Miller. U.S.P. 2,321,311, 8.6.43. Appl. 21.10.39. A motor-fuel composition consists of a mixture of gasoline hydrocarbons adapted as a base fuel for spark-ignition engines and at least 1% by volume of a heterocyclic compound containing a furane nucleus and selected from the group consisting of furane, alkyl furanes, furfuryl alcohols, furfuryl amines, and the saturated derivatives thereof.
H. B. M.

Lubricants and Lubrication.

455.* Reclamation of Lubricating and Other Oils. V. L. Farthing. *Petrol. Times*, 8.1.44, **48**, 16–22. (Extracts from paper read to Liverpool Engineering Society.)—To indicate the various methods of approach to the problem of reclamation of used oils, some of the systems of filtration, centrifuging, chemical treatment, and earth treatment applied to lubricating oils, transformer, turbine, switch oils, etc., are illustrated, and their methods of operation described. Consideration is given to the useful functions which these systems will perform and also to their limitations. Normally, filtered used lubricating oils are admixed with a lesser quantity of fresh oil before re-use, but recent research indicates that with Pennsylvania oils it is advisable to use fresh oil, topping up with the filtered used oil. The filtration and re-use of oils which originally contained additives or dopes are also discussed.

The opinion is expressed that acid and alkali treatments are suitable for application only in a refinery. At present in the U.K. used aero-engine oil is being reclaimed in quantity and re-used in modern aero-engines. For general application, systems involving earth treatment are considered to be the best for oil reclamation. A recent development, still in the experimental stage, is the treatment of transformer oil with activated alumina followed by filtration.
R. A. E.

456. Concentration of the Carcinogenic Material in a Venezuelan Spindle Oil by Simultaneous Molecular Distillation and Chromatographic Absorption. J. M. Twort and R. Lyth. *J. Hygiene Camb.*, 1944, **43**, 248–251.—Concentration of the carcinogenic material in a Venezuelan spindle oil has been effected by simultaneous molecular distillation, and further concentration has been accomplished by subjecting one of the more carcinogenic distillates to chromatographic absorption. By such means an extract was obtained which was ten times as carcinogenic on mice as the original oil.

The authors are of the opinion that they will eventually be able to show that it is unlikely that the liquid components of mineral oil, unless highly viscous, are responsible for the biological activity. Chromatographic analysis indicates that the most active constituents are highly viscous at room temperature, and it is thought that they may actually be crystalline solids.
T. C. G. T.

457. Prophylactic Effect of a Colloid Material on the Skins of Mice Painted with Various Types of Carcinogenic Agents. J. M. Twort and R. Lyth. *J. Hygiene Camb.*, 1944, **43**, 252–255.—A colloidal material S.D.2 containing as active constituents 30% tetrachlorethylene and 10% pine oil delays the advent of tumours on mice when used in conjunction with benzpyrene, coal gas tar, or shale oil. The protective action of this colloid exceeded that of lanolin when used with benzpyrene or coal gas tar, but afforded less protection than lanolin when used with shale oil.

The incorporation of 25% lanolin reduced the effectiveness of the colloid except for use with shale oil.
T. C. G. T.

458. Patents on Lubricants and Lubrication. C. F. Prutton. U.S.P. 2,318,629, 11.5.43. Appl. 4.3.38. An extreme-pressure lubricant consists of a major portion of mineral oil and up to 20% of an organic sulphur compound. The organic sulphur compound is of a type which, when included in the lubricant, does not show a substantial increase in reactivity with iron at temperatures below 100° C., but does show such an increase in reactivity at temperatures below 250° C.

C. F. Prutton. U.S.P. 2,318,630, 11.5.43. Appl. 8.8.38. The film strength of a mineral lubricating oil is increased by the addition of a liquid oil-miscible organic sulphur compound selected from the class consisting of the organic sulphides and organic disulphides.

H. G. Schneider and L. A. Bannon. U.S.P. 2,318,719, 11.5.43. Appl. 20.5.38. Lubricating oils are produced from *iso*butylene by conducting the polymerization in a series of successive stages. In this way the molecular weight is progressively increased up to lubricating-oil range. The first stage of polymerization is achieved with a non-volatile mineral-acid catalyst, and the products are re-polymerized to lubricating oils by means of a Friedel-Crafts type catalyst.

C. F. Prutton and A. K. Smith. U.S.P. 2,318,013, 4.5.43. Appl. 12.11.40. A lubricating composition is prepared from a suitable oil base, and a minor proportion of an oxygen and halogen bearing organic ring compound containing the carbonyl ($>C{=}O$) radical.

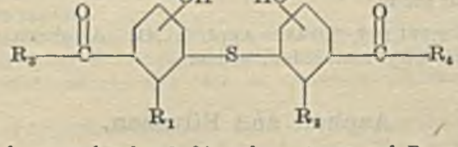
L. W. McLennan and O. W. Neukom. U.S.P. 2,319,076, 11.5.43. Appl. 24.10.39. A lubricating grease is prepared from mineral lubricating oil, 5–50% of an inert filler, and 15–40% of the saponification products of saponifiable materials selected from the group consisting of animal and vegetable waxes, of which at least half of the soap is a soap of such waxes.

O. M. Reiff. U.S.P. 2,319,189, 11.5.43. Appl. 19.4.40. A mineral-oil improving agent consists of an oil-miscible condensation product characterized by at least two aromatic nuclei, each of which is substituted with at least one oil-solubilizing alkyl group and with at least one aliphatic carboxylic acid group, wherein the carboxyl hydrogen is substituted with metal. The characterizing nuclei are interconnected by at least one atom of an element selected from the group consisting of sulphur, selenium, and tellurium.

O. M. Reiff. U.S.P. 2,319,190, 11.5.43. Appl. 20.4.40. A mineral-oil composition is improved by the addition of a small proportion of an oil-miscible condensation product characterized by at least two aryl nuclei, each of which is substituted with at least one alkyl group and with at least one other carboxylic acid group in which the carboxyl hydrogen is substituted with metal. The characterizing nuclei are interconnected by at least one atom of an element selected from the group consisting of sulphur, selenium, and tellurium. The alkyl substituents are aliphatic hydrocarbon groups of at least 20 carbon atoms.

M. H. Ittner. U.S.P. 2,319,405, 18.5.43. Appl. 3.8.40. In the manufacture of a lubricating grease, a substantially pure anhydrous soap in molten condition, substantially free from glycerine, unsaponified and volatile unsaponifiable matter, grit and other impurities, is mixed with a mineral-base lubricating material. The ingredients are mixed while the two substances are in a fused anhydrous condition, with substantial absence of air both during the mixing and cooling processes.

E. W. Cook and W. D. Thomas. U.S.P. 2,319,662, 18.5.43. Appl. 31.10.41. A lubricating composition consisting essentially of a mineral oil has incorporated in it a small amount of a compound selected from the group consisting of acid phenol monosulphides of the general formula.



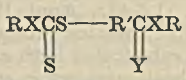
R_1 and R_2 are alkyl groups having 1–20 carbon atoms and R_3 and R_4 are members of the group consisting of alkyl, aryl, alkoxyalkyl, aroxyalkyl, arakyl, alkaryl and *cyclo*alkyl radicals, and metal salts thereof.

W. A. Lutz and J. W. Pool. U.S.P. 2,320,002, 25.5.43. Appl. 22.8.41. A thixotropic petroleum lubricating jelly having improved viscosity-temperature characteristics and improved lubricating properties at low temperatures, consists essentially of a mixture of a petroleum lubricating oil with a wax having a melting point above 150° F. It also has incorporated in it an amount of aluminium soap such that the ratio of soap to wax by weight is less than 1 : 1. The jelly is thus rendered substantially softer at low temperatures.

D. R. Frey. U.S.P. 2,320,228, 25.5.43. Appl. 18.7.40. A lubricant consists of a major proportion of a mineral lubricating oil and a small amount of an oil-soluble metal oxide of an ester of an aromatic acid with an aliphatic alcohol. The oxide is of the type in which the oxygen of the metal oxide group is directly attached to an aromatic ring.

V. N. Jenkins. U.S.P. 2,320,241, 25.5.43. Appl. 21.11.39. A lubricant is prepared from mineral lubricating oil and 0·8–2·0% of an oil-soluble alkaline-earth metal soap of organic acid of the class consisting of gamma and higher position hydroxy aliphatic acids capable of forming lactones, gamma, and higher position amino-aliphatic acids capable of forming lactams, amino-aliphatic acids capable of forming lactims and lactimides, and cyclic hydroxy acids capable of forming lactones. The product is designed to avoid corrosive conditions towards corrosion sensitive alloy bearings without substantially increasing the viscosity of the original lubricating oil.

E. Lieber and L. A. Mikeska. U.S.P. 2,320,287, 25.5.43. Appl. 7.4.39. A lubricant consists of a mineral oil and a small quantity of a compound having the formula



$$\mathrm{RX}\underset{\underset{\displaystyle \mathrm{S}}{\|}}{\mathrm{C}}\mathrm{S}\text{——}\mathrm{R'}\underset{\underset{\displaystyle \mathrm{Y}}{\|}}{\mathrm{C}}\mathrm{XR}$$

R and *R'* are organic radicals, *X* is an element selected from the class consisting of oxygen, sulphur, selenium, and tellurium, and *Y* is an element selected from the class consisting of hydrogen and a negative element of Group VI of the Periodic System.

R. M. Thomas and W. J. Sparks. U.S.P. 2,320,312, 25.5.43. Appl. 4.1.38. A thickened mineral oil composition having high stability consists of a mineral oil base stock and the product obtained by the reaction of 1 part of an *iso*-olefin polymer of 1000–50,000 molecular weight with ½–2 parts by weight of sulphur chloride. The reaction is carried out at a temperature between 100° and 200° C., and is continued until the polymer is converted into a product of considerably higher molecular weight which contains less than 1·3% of chemically combined sulphur and less than 1·5% of chemically combined chlorine.

E. R. White. U.S.P. 2,320,392, 1.6.43. Appl. 13.1.41. An anti-ring-sticking lubricant is prepared from mineral lubricating oil and 0·25–5% of an oil-soluble polyvalent metal salt of an α-amino-acetic acid. The lubricant is resistant to oxidation under normal conditions in internal-combustion engines.

L. A. Mikeska and E. Lieber. U.S.P. 2,321,307, 8.6.43. Appl. 17.8.37. A lubricant suitable for use in internal-combustion engines consists of a refined hydrocarbon oil containing an effective concentration of an oxidation inhibitor which prevents decomposition of the oil. The oxidation inhibitor is a compound of the class of organic phosphites containing an element selected from the class consisting of sulphur, selenium, and tellurium. This element is directly attached to the phosphorus and the organic group.

R. Rosen. U.S.P. 2,321,517, 8.6.43. Appl. 2.1.41. A lubricant has dissolved in it 0·05–5·0% of tetra-*n*-butyl ammonium iodide. H. B. M.

Asphalt and Bitumen.

459. Patent on Asphalt and Bitumen. R. A. Dunham. U.S.P. 2,318,932, 11.5.43. Appl. 30.1.40. An emulsion of the oil-in-water type having a demulsibility above 60 and a viscosity below 55 secs. Saybolt furol at 77° F. is produced from an asphalt which will not normally emulsify to produce an emulsion having these characteristics in the following manner. The asphalt is heated to a temperature between 625° and 700° F., for a period of time greater than 30 min. Afterwards the heated asphalt is mixed with water and a small amount of an emulsifying agent to obtain the desired emulsion. H. B. M.

Special Products.

460. Kerosine has Extensive and Varied Field of Service. A. W. Trusty. *Petrol. Engr*, May 1943, 14 (8), 118.—This article gives a review of the present applications and desired qualities of kerosine.

Contrary to what might be expected, production of kerosine in the U.S.A. is increasing, although the percentage yield from crude has steadily decreased during the last forty years.

The application to illumination is still the most important, but it is predicted that its use as a heating agent will soon take the lead.

As an illuminant, the three requisites of a kerosine are stated to be

(1) it must give a flame of good initial candle power;
(2) it must maintain this candle power as the oil burns;
(3) it must not give rise to excessive deposits of film on the chimney.

(1) Depends on the chemical composition of the kerosine and on the design of the lamp. Paraffin hydrocarbons give the greatest flame height and, although aromatics give more luminosity for a comparable area of flame, the decrease in flame size lessens the total candle power. The I.P. Smoke Point apparatus is considered the best means of measuring flame size, and typical results are quoted for paraffinic and aromatic kerosines. Lamp design has also a marked bearing on the burning quality of the kerosine.

(2) Depends on the maintenance of a constant supply of kerosine to the wick and complete combustion without char formation. The supply of oil to the wick will depend on lamp design and correct oil viscosity. Char formation is dependent upon hydrocarbon composition and on lamp design and may be measured by suitable lamp tests.

(3) Depends on hydrocarbon composition and the presence of impurities such as sulphur compounds, whilst factors such as chimney design and temperature, draught and purity of atmosphere affect the formation.

Colour instability in kerosine is considered to be of several different types and the oxidation type (developing in the dark) may be measured by the Hillman lead peroxide test. Other types are attributed to amino-compounds and to unsaturated bodies.

Some colour stability tests and the A.S.T.M. tests for burning quality are described.

Blue flame burners, vaporizing appliances and other uses of kerosine, *e.g.*, as tractor fuel, are referred to briefly. J. C.

461. Testing Elasticity of Synthetic Rubbers at Low Temperatures. G. D. Kish. *Petrol. Engr*, May 1943, 14 (8), 128.—An instrument called the "Elastensometer" has been developed in order to measure the elastic properties of synthetic rubber compounds at low temperatures, particularly with regard to their present-day emergency use in place of natural rubber in coupling gaskets for pipelines, etc.

A small beam of the material is supported on anvils and centrally loaded. The force required to produce a constant deflection is measured at various temperatures and the force/temperature curve plotted. The critical limit of normal elastic properties is reached at that temperature where the force required to produce constant deflection increases rapidly.

The construction and operation of the instrument are described in detail, and diagrammatic and photographic illustrations are provided. Advantages are simplicity, economy of time and material and ease of operation. A sample can be tested in 15 min.

In a discussion of typical results, the usual curves given are shown. By means of the conventional formula for the deflection of a beam the modulus of elasticity (E) may be calculated and curves plotted showing the changing values of E with decreasing temperature. J. C.

462.* Method of Testing Elasticity of Synthetic Rubbers at Low Temperatures. George D. Kish. *Oil Gas J.*, 3.6.43, 42 (4), 43.—See Abstract No. 461. C. G. G.

463.* Canada's Synthetic Rubber Programme. C. C. Pryor. *Petrol. Engr*, October 1943, 15 (1), 138–144.—Canada and the U.S.A. have co-operated in pooling available stocks of natural rubber and information regarding the manufacture of synthetic rubber. Equipment not available from Canadian sources has also been supplied by the U.S.A. For reasons given it was decided to manufacture the butadiene required from petroleum sources, thus also obtaining the ethylene required for styrene production, and *iso*butylene for butyl rubber manufacture. These products were obtained by extending the cracking facilities available at one of the largest Canadian refineries, which is also conveniently situated in relation to the largest tyre manufacturers, thus reducing transport requirements.

The synthetic rubber plants are situated at Sarnia, Ontario, and are expected to be in production in the near future. Quantities of 34,000 tons of Buna S and 7000 tons of butyl rubber p.a. are indicated. A Thiokol plant has also been erected in Ontario, and began full scale operations on 14th June.

Future possibilities in connection with the production of butadiene from alcohol obtained from wheat are discussed. Active research is in progress with a view to producing quantities of natural rubber gum from milkweed and other plant sources. This natural rubber may be blended with Buna S, and is said to improve certain properties of the latter when used for tyre manufacture. R. A. E.

464.* Utilization of Synthetic Rubber in Oil Industry. W. A. Sawdon. *Petrol. Engr*, November 1943, **15** (2), 76–80.—A company has been experimenting for a number of years with a view to utilizing synthetic rubber blends in replacement of the natural product for manufacture of such oil-field equipment as casing protectors, pipe-wipers, wire-line guides, etc. The particular synthetic developed is known as PBX, and is now being used for the purposes mentioned.

Differences in technique in the fabrication and handling of the synthetic as compared with the natural product are necessary, and experience has been accumulated. Casing protectors manufactured with the new material have been in service for some time, but not long enough to determine ultimate life. Resistance to abrasion is said to be adequate for the service, and advantages over natural rubber in respect of deterioration due to climatic conditions and contact with oil and gas are claimed. Although the ultimate strength of the natural rubber is greater than that of the synthetic, the tensile strength of the latter is the greater at elongations required in service and installation. This means better adherence of the protector to the pipe, but necessitates the employment of increased power to instal and remove the protector. R. A. E.

465.* Flex Life and Crystallization of Synthetic Rubber. J. H. Fielding. *Industr. Engng. Chem.*, 1943, **35** (12), 1259.—Experimental data are presented which show that natural rubber and Butyl B are similar in that stretching produces fibreing. G. R.–S. and Buna N do not show fibreing, and gum stocks have a low tensile strength and poor flex life. J. W. H.

466.* Oils in the Cold Rolling Mill. M. Roswick. *Petroleum*, 1944, **7** (1), 6. A précis of a paper and discussion published in *Iron and Steel Engr*, 1943, **20** (3), 73.—The functions of an oil used in the high-speed cold rolling of metal sheets are to act as a lubricant and coolant, and in some degree as a protective coating on the finished sheet.

It is believed that some penetration of the oil into the surface interstices of the metal takes place, so that low surface tension coupled with good adsorption properties are essential properties of the oil. These properties are characteristic of vegetable and animal oils, which, however, are less satisfactory than mineral oils in respect of surface finish obtainable. The advantages of both classes are obtained by suitable blending of mineral and fatty oils.

In the U.S.A. the main classifications of oils for cold rolling are : (1) mineral oils, 50–200 secs. S.U., (2) compounded mineral/fatty oils ; (3) soluble-oil emulsions ; (4) soluble-oil and palm-oil emulsions ; (5) straight palm oil. Personal preference is often the deciding factor.

Compounded oils with properties closely resembling those of palm oil are being developed with considerable success, but details of their precise nature are not available. C. G. G.

467. Cresols Separation. Anon. *Chem. Tr. J.*, 14.1.44, **114**, 36.—E.P. 557,519 of 1942 granted to Shell Development Co. describes a method of separating *meta*- and *para*-substituted cresols and allied products (which generally have very close boiling points) by a further alkylation step carried out with only a limited amount of alkylating agent so that the reaction takes place very largely in the *para*-position only. Hence the more highly alkylated *para*-product can be separated by distillation from the *meta*-product. Alkylation may be carried out by olefins, alkyl chlorides, alcohols, or ethers, at varying temperatures between 0° and 100° C. and using preferably less than 7% of alkylating agent over the equivalent required for alkylating in the *para*-position. In an example quoted, 85% of the unreacted *meta*-product is recovered. The alkylated *para*-substituted alkyl phenols are useful as oxidation inhibitors in gasolines and other products, whereas the *meta*-products are of little anti-oxidant value. C. L. G.

468. Patent on Special Products. A. Jenkner. U.S.P. 2,319,326, 18.5.43. Appl. 15.10.40.—A bitumen-like product is produced from a mixture of glance coal and a hydrocarbon oil of high boiling point. The product in colloidal state has a softening point greater than 90° C. and a breaking point of less than 0° C. H. B. M.

INSTITUTE NOTES.

MARCH 1944.

APPLICATIONS FOR ADMISSION OR TRANSFER

The following have applied for admission to the Institute or for transfer. In accordance with the By-Laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Membership.

BREWER, Charles Dunstan, Engineer, Shell Refining & Marketing Co., Ltd. (*John A. Oriel; R. I. Lewis.*)

EVANS, Ifor Wyn, Research Engineer, Shell Refining & Marketing Co., Ltd. (*G. Davidson; J. Grant.*)

JENKINS, Colin Rees, Technical Adviser, Shell-Mex & B.P., Ltd. (*G. Davidson; J. G. Hancock.*)

JOHNSON, Wilfred, Chief Inspection Officer, A.I.D.

KENYON, Arthur James Frederick, Chemist, Esso European Laboratories. (*F. H. Garner; W. E. J. Broom.*)

McGRATH, Leonard, Laboratory Assistant, Lobitos Oilfields, Ltd. (*V. Biske; J. M. Harkess.*)

RAIT, Frank Percy, Technical Director, Messrs. Percy & Halden, Ltd. (*N. L. Skilling; Walter Kay.*)

SANDERS, Harold William Frederick, Branch Manager, Colas (S.A.), Ltd. (*L. J. Gabriel.*)

SEDLEY, Walter Thomas, Laboratory Assistant, Lobitos Oilfields, Ltd. (*V. Biske; J. M. Harkess.*)

SELLERS, Ernest Stanley, Chemical Engineer, Manchester Oil Refinery, Ltd. (*E. J. Dunstan; G. H. Harries.*)

STURGESS, Herbert Leslie, Chief Chemist, Shell-Mex & B.P., Ltd., (*J. W. Vincent; D. A. Yonge.*)

TAYLOR, Alec, Research Chemist, Newton Chambers & Co., Ltd. (*J. S. Jackson; L. Ivanovsky.*)

TRUEMAN, Fred Norman, Chemist, Spurrier, Glazebrook & Co., Ltd. (*Harold Moore.*)

Transfer.

JENKIN, James Edmund Earl (Associate Member), Manager, Engineering, Anglo-American Oil Co., Ltd. (*E. Evans-Jones; C. Chilvers.*)

JEWELL, John Christopher (Associate Member) Chemist, Attock Oil Co., Ltd. (*J. G. H. Jeffrey; A. E. Chrisman.*)

McKEE, John Lockhart (Associate-Member), Deputy Director, Ordnance Laboratories.

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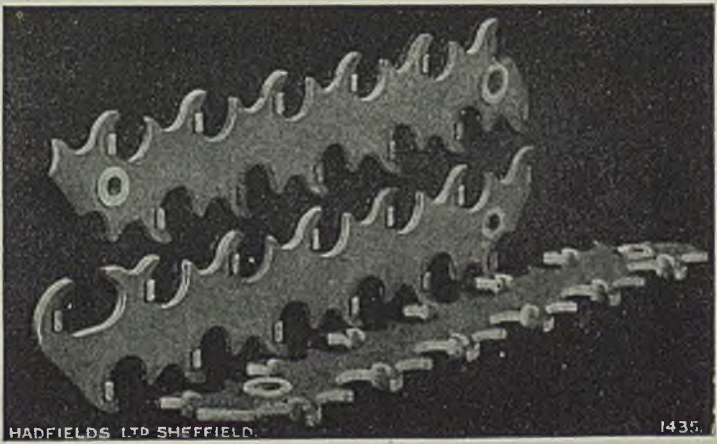
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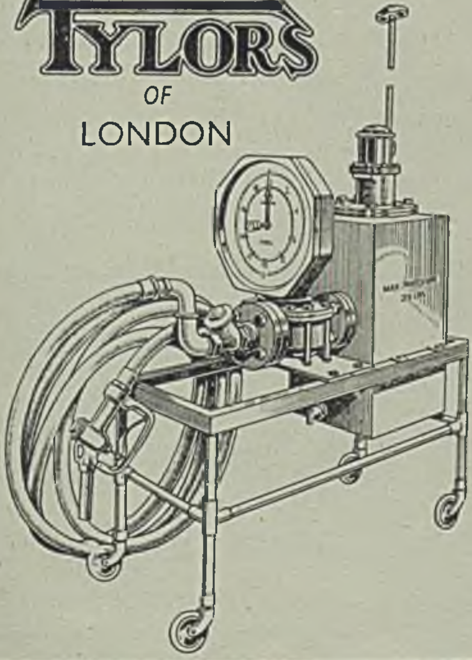

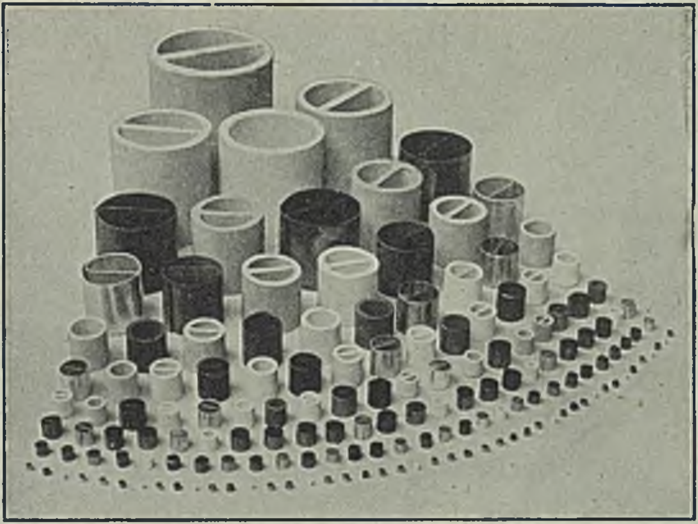

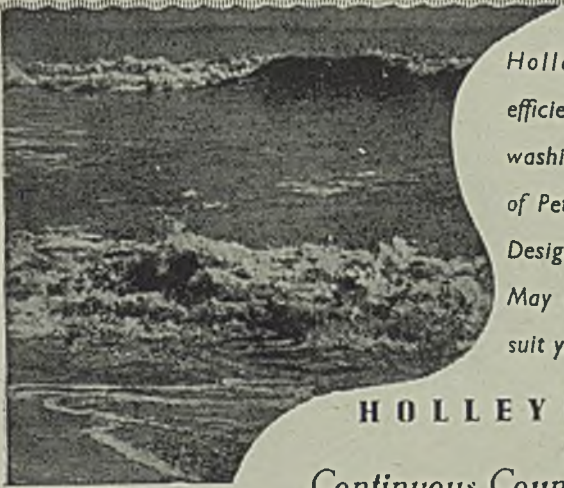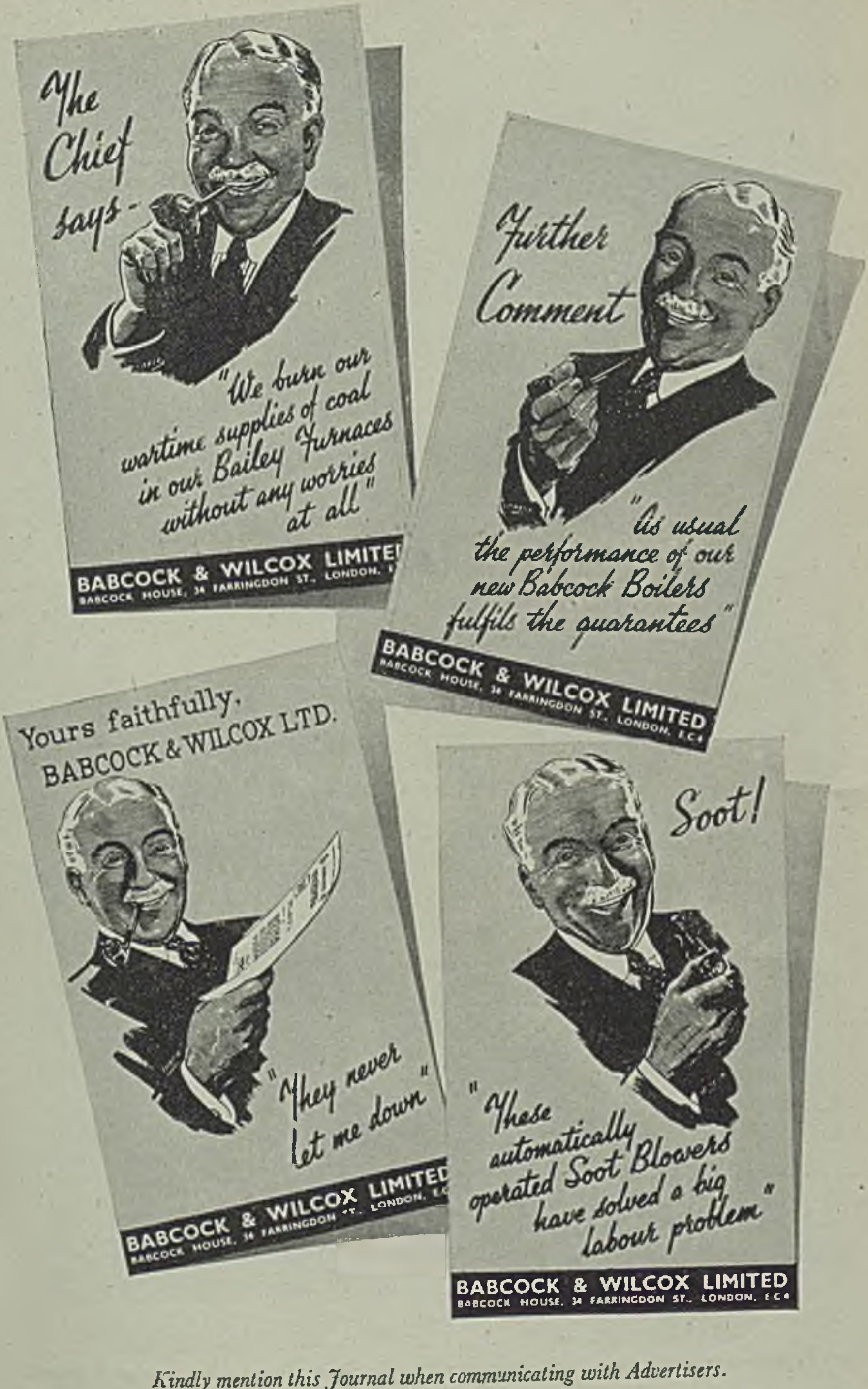

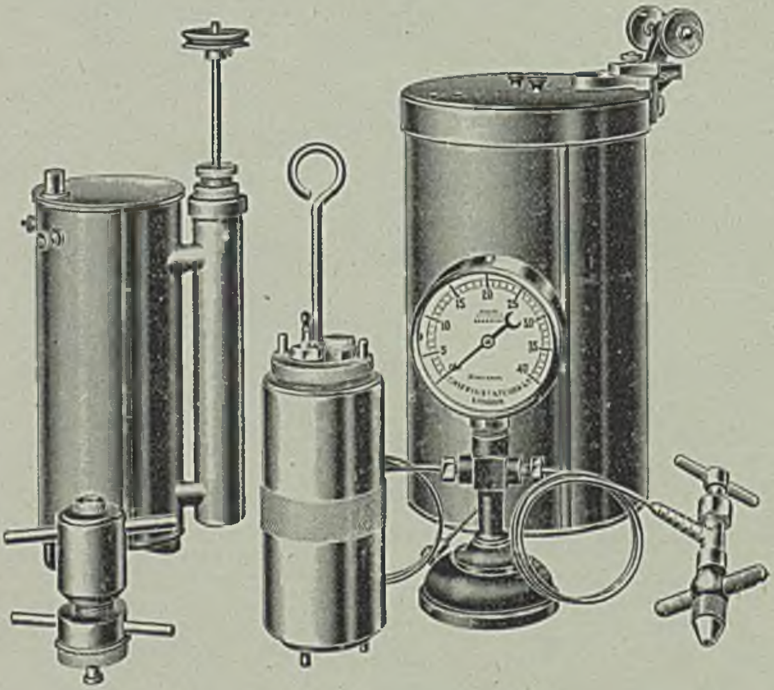

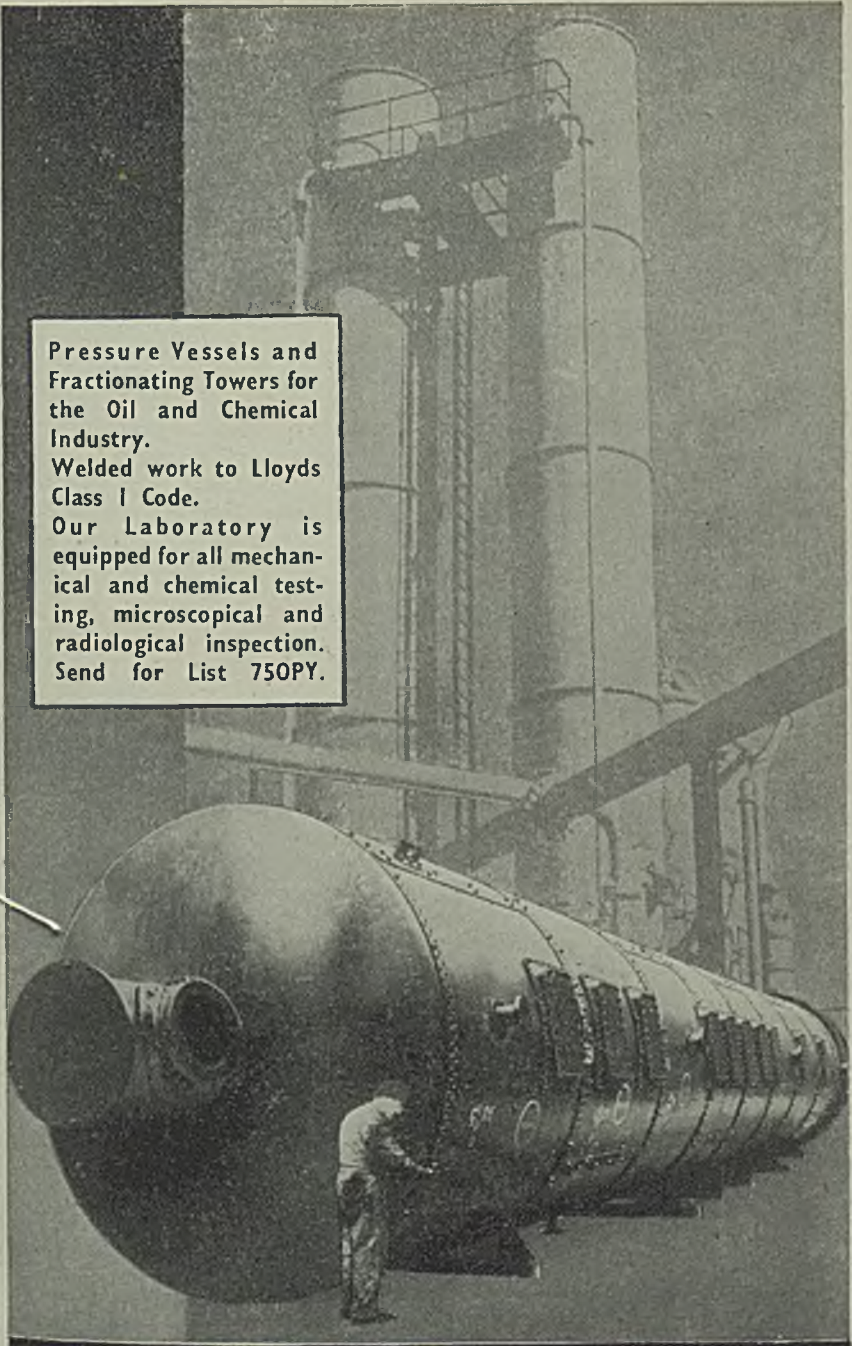

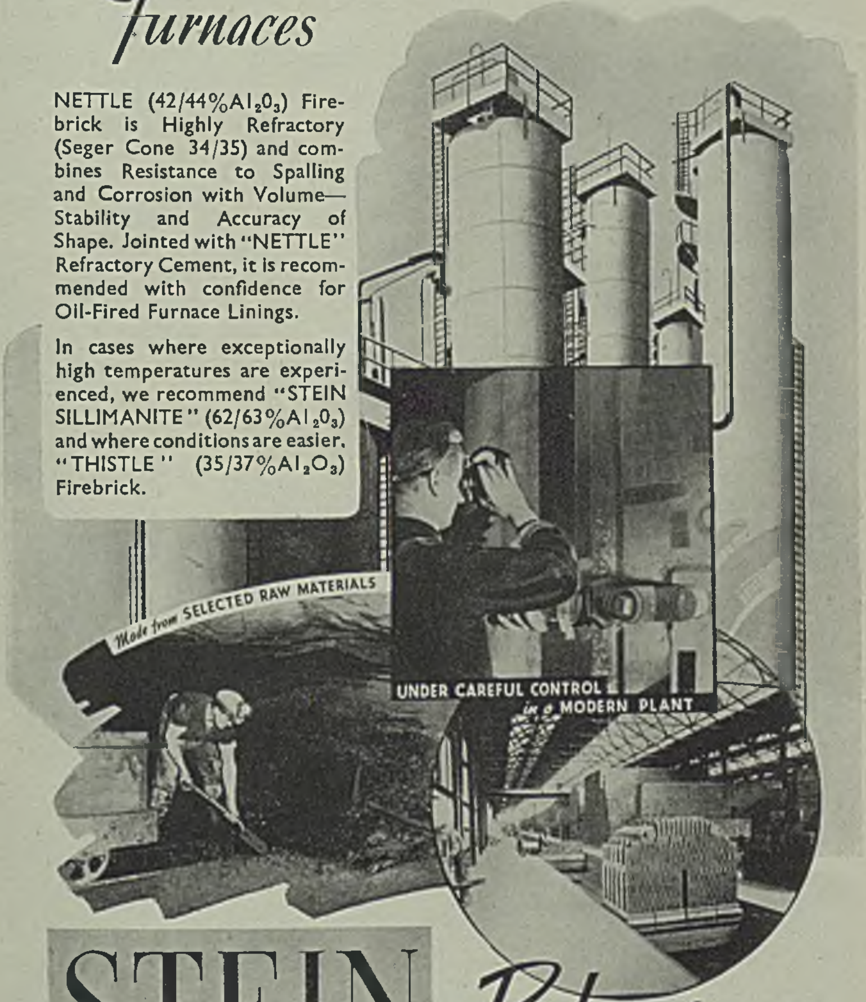

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